M1A2 ABRAMS MAIN BATTLE TANK 1993–2018









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NEW VANGUARD 268

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INTRODUCTION

The M1 Abrams tank was developed at the height of the Cold War in the 1970s and has remained in service for four decades. It has seen extensive combat in several conflicts in the Middle East and is one of the most widely exported tanks of the post-Cold War era. Production for the US armed forces ended more than two decades ago, since when the Abrams has undergone a continual array of modifications and upgrades to keep it up to date. Like many of the classic tank designs of the late Cold War period, including the British Challenger 2, German Leopard 2, and Soviet/Russian T-72/T-90, the Abrams tank is likely to remain in service for decades to come. The Abrams tank has been covered in previous books in this series, so the focus of this book is on the technical evolution of the Abrams tank after Operation *Desert Storm*.[1]

DESIGN AND DEVELOPMENT

During the early 1970s, the US Army was equipped with M60A1 tanks as well as smaller numbers of M48A3 tanks in National Guard units. These types were an evolutionary development of the M26 Pershing tank of 1945. There were several attempts to replace this series with a completely new design, all of which were eventually canceled.

The most recent effort was the MBT-70 program which began in 1963 as a joint program by the United States and Germany to develop a common tank. This program was canceled in December 1969 due to the extremely high price of the tank, estimated to cost $850,000 (Fiscal Year 1969–FY69). In its place, the US Army attempted to develop an austere variant, the XM803, with a unit cost of $600,000. This program was canceled by Congressional action in December 1971 due



An M1A2 SEPv2 of 2-5th Cavalry, 1st Cavalry Division during exercise *Combined Resolve II* in Germany on May 26, 2014. This tank has the CARC Tan CIP Combat Identification Panels and is fitted with the I-MILES laser-simulation training equipment. (US Army/Spc. John Cress Jr)

1 Steven Zaloga, *The M1 Abrams Battle Tank*, Osprey Vanguard 41 (1985); Steven Zaloga, *M1 Abrams Main Battle Tank 1982–92*, Osprey New Vanguard 2 (1993).



This is the original Chrysler XM1 validation phase pilot prior to the incorporation of the Burlington armor on the turret. It had numerous other differences including the use of an M60D 7.62mm machine gun for the loader and an M85 .50cal heavy machine gun for the commander. (US Army)

to concern that the tank was too sophisticated and too expensive. It should be recalled that this program was underway in the midst of the Vietnam War, and that the Army suffered from severe budget constraints as a result. The XM815 New Main Battle Tank (NMBT) study program began in January 1972.

The MBT Task Force under Maj Gen William Desobry concluded that a new tank was needed due to deficiencies in the M60A1 tank compared to contemporary Soviet tanks. The M60A1 suffered from an excessive silhouette, inadequate acceleration and cross-country speed, unacceptable reliability of the powertrain and armament system, lack of adequate firepower on the move, and insufficient ballistic protection against modern APFSDS (armor-piercing, fin-stabilized, discarding-sabot) projectiles.

The Office of the Secretary of Defense (OSD) approved the start of the XM1 program in January 1973 with a stern warning about price constraints. The hardware cost objective was put at $507,790 ($FY72) for a production run of 3,312 tanks. By way of comparison, the M60A1 tank cost $339,000 at the time. One of the main cost-drivers between the XM1 and M60A1 was the use of a thermal-imaging night sight on the XM1 which amounted to nearly a quarter of the tank's cost. The program configuration was a competitive design effort with Ford, General Motors, and Chrysler receiving Army requests. Eventually, Ford decided against joining the program and two development contracts were awarded in June 1973.

Propulsion for the XM1 was one of its most controversial features. The army had sponsored the development of a tank gas-turbine engine in the 1960s, the AVCO-Lycoming AGT-1500. It was first considered for the MBT-70 in place of more conventional diesel engines. The army's enthusiasm for the gas-turbine option was the result of the revolutionary improvement in army helicopter propulsion due to gas-turbines. Gas-turbines are a form of jet engine, but with the power output through a transmission rather than jet exhaust. Compared to contemporary piston engines in terms of comparable size and weight, the gas-turbines were significantly smaller and lighter. In helicopter use, their simplicity led to lower maintenance demands and greater reliability.



The XM1 Full-Scale Engineering Development Pilot Vehicle #1 is seen here at the Detroit Army Tank Plant in February 1978. Some of the pilot tanks and low-rate initial production tanks carried the MERDC four-color camouflage as seen here. (US Army)

There were some notable challenges in adapting gas-turbines to tanks, especially their voracious consumption of fuel and air. Unlike conventional piston engines which can be slowed to idle to conserve fuel when the tank is not moving, the gas-turbine operates near peak power all the time, consuming fuel. In addition, the engine requires a substantial flow of air, which is a more significant problem in a land-combat environment than on helicopters due to the continuous presence of dust which can erode engine parts. In the end, Chrysler selected the more controversial turbine for its XM1 design while General Motors stuck with an AVCR-1360 diesel. Although both engines were rated at 1,500hp, the actual power available from the turbine was greater since only about 30hp had to be expended for engine cooling while the diesel required about 160hp for cooling.

Several armament options were considered for the XM1, including the existing M68 105mm gun, a British 110mm gun, and the German Rheinmetall 120mm gun. Besides these basic options, there was consideration given to a next-generation guided 105mm projectile called Swifty, as well as the possible use of a co-axial 25mm Bushmaster automatic cannon to deal with the threat of light armored fighting vehicles. Although the Tripartite Gun Trials by Germany, the UK, and the USA in 1975 concluded that the German 120mm gun was the best-suited to meet the long-term threat, in January 1976, OSD approved the Army decision to stick with the 105mm gun in the initial production series of the XM1 since the baseline threat was considered to be the Soviet T-62 tank.

The XM1 requirements called for armor protection against the Soviet T-62 tanks' 115mm APFSDS projectile at 800–1,200 meters and the AT-3 Sagger missile's 127mm HEAT (high explosive antitank) warhead over a 50-degree frontal arc. Protection was sufficient to defeat the RPG-7 rocket launcher at 45 degrees on the crew compartment sides and at all angles against the turret side. The initial designs of the XM1 used conventional steel armor.

Since 1964, the British Army's FVRDE research facility at Chobham had kept the US Army informed about their research on Burlington "special armor." This was an armor package consisting of modules with spaced



The 2nd Armored Division at Fort Hood, Texas, was one of the first units equipped with the new M1 Abrams tank in 1982–83. This column is from 3-67th Armor. (Author)

laminates of steel and other materials fitted over conventional welded steel armor. Burlington offered much superior performance to steel armor in the defeat of shaped-charge HEAT warheads, while at the same time being equivalent to conventional steel armor in defeating APFSDS kinetic energy penetrators. The UK and the US began discussions on a memorandum of understanding about the development and use of Burlington armor in 1969, but plans to incorporate it into the XM1 design do not appear to have begun until 1973 after the start of the program. A major incentive for adopting Burlington armor was the Israeli combat experience in the 1973 Yom Kippur War. The Israeli tank force suffered heavy losses at the hands of RPG-7 antitank rocket launchers and AT-3 Sagger (9M14M Malyutka) antitank missiles. The initial pilots of the XM1 program during the validation phase had conventional steel armor but the turrets and hull were redesigned to incorporate an improved version of Burlington armor developed in conjunction between the FVRDE and the Ballistics Research Lab (BRL) at Aberdeen Proving Ground (APG) in Maryland.

Besides the armor package, the XM1 designs began to explore other methods to protect the crew. The primary source of catastrophic tank loss in combat is the ignition of main gun ammunition propellant. To minimize the hazard posed by the ammunition, tank designers since World War II advocated transferring the ammunition to the floor of the tank where it was least likely to be hit. This configuration is no guarantee that the ammunition will not be hit, since mine damage or ricocheting projectile fragments inside the tank can set it on fire. Furthermore, the floor location is difficult for loaders to reach, especially in view of the growing weight and size of modern tank ammunition. The US Army began to explore the idea of moving the ammunition into a bustle at the rear of the turret. The ammunition compartment could be separated from the fighting compartment by sliding blast-doors, and only open for a short time when the loader extracted a round. Should the ammunition be set afire, the blast doors would protect the crew long enough to escape, and in many cases would slow or prevent the spread of a catastrophic fire into the rest of the tank.

The IPM1 introduced some of the features developed for the M1A1 including the better armor package, but retained the 105mm gun. This IPM1 is seen here at the National Training Center at Fort Irwin, California, in the Mojave desert in a locally applied camouflage scheme. (Author)



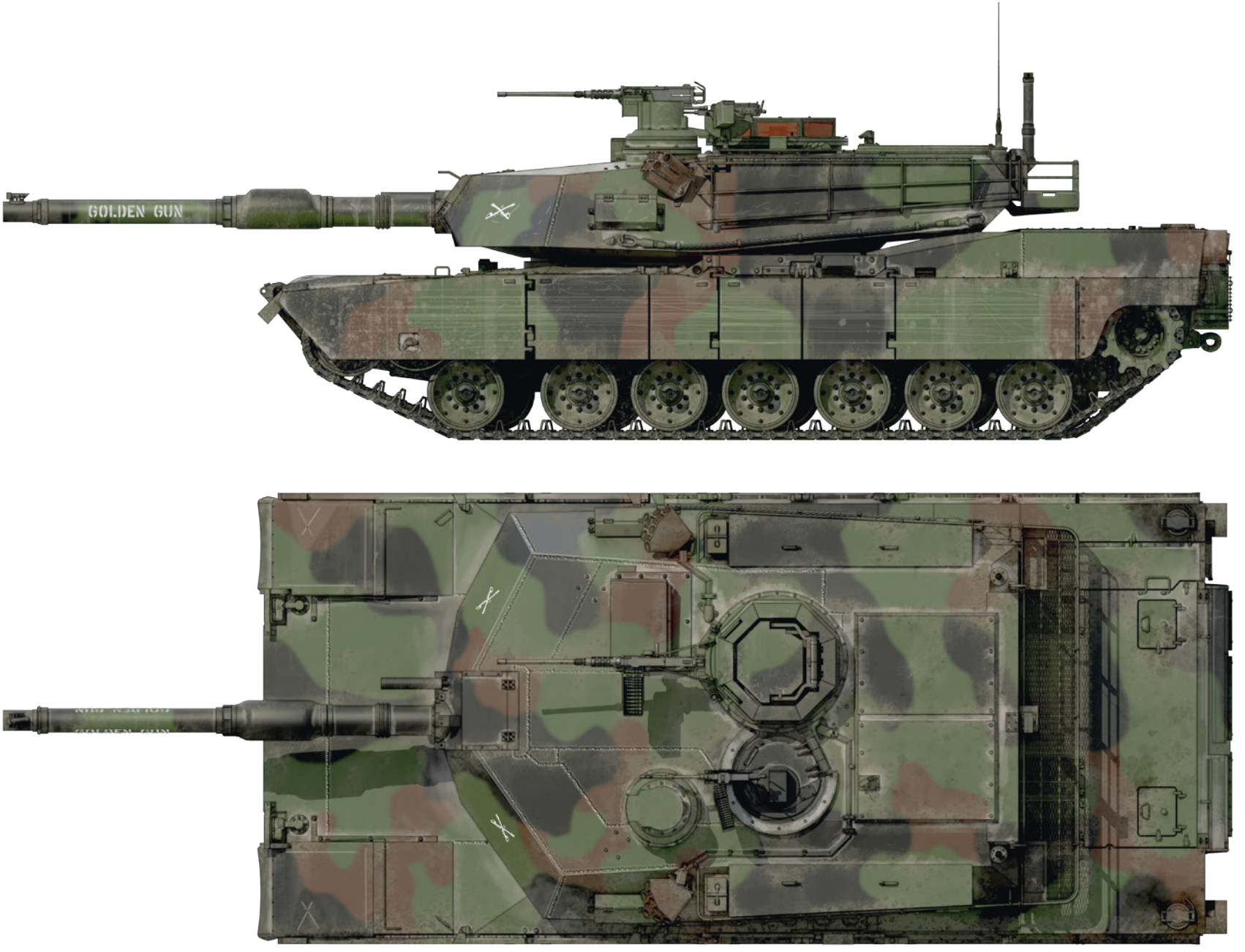
The developmental and operational trials of the validation phase pilot tanks were conducted at APG in January–May 1976. In the meantime, the OSD acceded to a German request to consider joint production of the new Leopard 2 tank. The Leopard 2AV (American variant) underwent trials at APG in the fall of 1976. The Leopard 2 was judged to have superior fire controls, but inferior armor, ammunition compartmentalization, and gun traverse. The main problem was cost. FMC Corp teamed with Krauss-Maffei in Germany to build the Leopard 2AV at their San Jose plant if it was selected by the US Army. FMC conducted a study for the US Army that concluded that the Leopard 2AV would cost 25 percent more than either of the XM1 pilots to manufacture in the United States. As a result, the Leopard 2AV was withdrawn from consideration. Both governments agreed to consider using common components, including the American AGT-1500 turbine engine and the German 120mm gun.

The first set of trials led the US Army to favor the General Motors design, but the performance of the AGT-1500 was favorable enough that the Army considered incorporating it into the General Motors pilot. OSD insisted that both General Motors and Chrysler redesign their turrets to potentially accommodate the German 120mm gun. The Chrysler team, under Dr Phillip Lett, used this opportunity to substantially redesign the turret to incorporate

A

M1A2, G TROOP, 1-16th CAVALRY, FORT KNOX ARMOR CENTER, KENTUCKY, 2002

The M1 Abrams main battle tank entered production as the US Army was shifting from the MERDC (Mobility Equipment Research and Development Command) four-color camouflage system to the NATO three-color system, called "Europe 1" in the US Army. Until the US Army adopted the necessary camouflage paint, tanks were delivered in overall Forest Green (Federal Standard FS 34079). The appropriate pattern for the M1A1 and M1A2 was released in 1987 and is shown here in the "Europe 1" colors. The three colors for "Europe 1" were Green 383 (FS 34094), Brown 383 (FS 30051), and Black (FS 37030) and were designed to duplicate the three colors originally adopted by the German Bundeswehr. This switch coincided with the adoption of CARC paint in May 1983. Chemical Agent Resistant Coating is a paint designed to provide visual and infrared camouflage to military vehicles while at the same time being resistant to chemical warfare agents and decontaminating materials. The pattern was applied at the factory and the colors were airbrushed with a slightly feathered edge.


GOLDEN GUN



The Marine Corps requirement for adapters to attach the Deep Water Fording Kit led to the M1A1 Common Tank, which was manufactured at the tail end of M1A1 production for both the US Army and Marine Corps. (Author)

the Burlington armor, and to make a number of fire control upgrades. At the same time, other changes were made to drive down unit cost, a major criteria in the OSD evaluations.

In the event, the modified Chrysler design was selected on November 12, 1976 to proceed to full-scale engineering-manufacturing development (FSED). The FSED phase involved the construction of 11 pilot tanks, the first of which was delivered in February 1978. In August 1976, the Army selected the Lima Army Tank Plant (LATP) as the primary production facility, with the Detroit Army Tank Plant (DATP) as the secondary source. In July 1977, the production objective for the XM1 was increased to 7,058 tanks.

Trials of the XM1 pilot tanks were satisfactory enough that a low-rate-initial-production (LRIP) contract was awarded on May 7, 1979 for the first 110 LRIP tanks, funded in the FY79 budget. The first production tank was delivered by Lima in February 1980 and the tank was type classified as the M1 tank in February 1981. It was named after Creighton Abrams, the army chief-of-staff during the later part of the Vietnam War, and a World War II tanker. Abrams had been instrumental in pushing along the XM1 program in spite of many political and budget hurdles, but had died at an early age in 1974 before the program reached completion.

Chrysler Defense was sold to General Dynamics in March 1982, becoming the General Dynamics Land Systems division (GDLS). The LRIP tanks were issued to the 2-5th Cavalry at Fort Hood, Texas, for the third and final set of operational trials, and they were also used for a variety of extreme weather tests. The first tanks from the Detroit plant were delivered in March 1982. By the summer of 1982, 585 tanks had been delivered, all trials had been completed, and five battalions of M1 tanks were deployed, three in Europe and two in the US. The last basic M1 was completed in January 1985.

Alongside the development of the XM1 tank, there was a parallel effort to develop improved tank ammunition for its M68A1 gun. The APFSDS projectile using a depleted uranium penetrator, the 105mm M774, entered service in the summer of 1981, followed by the improved M833 in the fall of 1983. There was also a new 105mm HEAT round, the M815, which entered service in the spring of 1987.



THE M1A1 ABRAMS MBT

By the time that the M1 tank was approaching production, it was appreciated that the Soviet tank threat had already changed with the advent of the newer T-64 and T-72 tanks, armed with a 125mm gun. Although precise details of Soviet tank armor were not known at the time, there was the presumption that the Soviet Union would adopt some form of special armor that could resist the 105mm gun. On 31 January 1978, the US Army approved the adoption of the German Rheinmetall 120mm smoothbore gun on a future production version of the M1 tank. This decision led to the start of the M1E1 Block 1 program in June 1979. The German gun was simplified and adapted to American manufacturing techniques at the Watervliet Arsenal in New York, and the first example of the XM256 120mm gun delivered in April 1980.

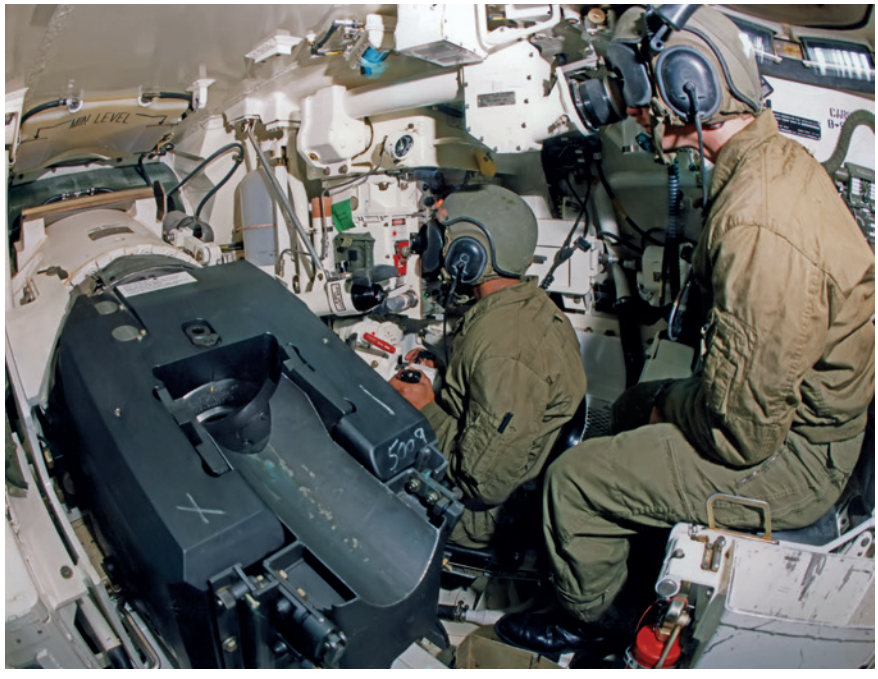
Besides the new gun, a variety of other improvements were being developed as part of a "Block" upgrade effort. This included a new generation of special armor to deal with the Soviet 125mm tank gun, a hybrid NBC (nuclear, biological, chemical) protective system, a micro-cooling vest for operations in hot weather, and a variety of suspension, transmission, and final drive upgrades. The first M1E1 pilots were delivered in March 1981. Details of the upgraded armor package remain secret, but a Soviet report assessed the armor protection of the M1A1 against APFSDS to be equivalent to 600mm RHA (rolled homogeneous armor) compared to 470mm for the M1, and 700mm against HEAT compared to 650mm for the basic M1.

The Block improvements on the M1E1 were readily adaptable to the production line, and so the Army decided

The CATTB (Component Advanced Technology Testbed) was built in the early 1990s to examine possible systems for future variants of the M1A2 Abrams tank including the XM291 140mm ATC Advanced Tank Cannon. This pilot of the CATTB is seen with its turret traversed to the rear for rail transport. (Author)

In the early 1990s, the Army began installing External Auxiliary Power Units in the rear bustle rack on the M1A1 tank. These were used to power the tank when in Silent Watch Mode with the main engine turned off to conserve fuel. This is an example on an M1A1 AIM. (Author)





A view of the right side of the turret of the M1A1 Abrams with the 120mm gun breech in the foreground. The tank commander, seen here to the right, viewed the target via an optical adjunct to the Gunner's Primary Sight. The gunner can be seen to the left in front of the tank commander. (US Army)

to manufacture the final series of M1 in an Improved Production IPM1 configuration. A total of 2,374 basic M1 tanks were manufactured through January 1985, and the IPM1 entered production in October 1984, with 894 manufactured through May 1985. The IPM1 included all of the upgrades envisioned on the M1E1 except for the 120mm gun and NBC suite. The first IPM1 tanks were deployed with C Company, 2-69th Armor at Fort Benning in early 1984.

Consideration was given to the adoption of a Commander's Independent Thermal Viewer (CITV) on the M1E1. The tank commander on the baseline M1 tank could view the thermal images captured by the gunner's sight via an optical elbow, but the CITV would have provided an independent sight that the commander could employ to hunt for targets. Although this "hunter-killer" concept was strongly favored, thermal sights during this period were very expensive. As a result, the CITV was not incorporated on the M1E1, although a circular roof opening was added to the design so that a CITV could be easily added at some future point in time.

Another upgrade under study at the time was an auxiliary power unit (APU). The APU was desired since the electrical demands of the fire control system and other vehicle electronics would quickly drain the tank batteries when the engine was not running. As a result, the turbine engine had to be used to keep the electronics powered even when the tank was stationary. Unlike a conventional engine, a turbine operates near peak power at all times, and this was inefficient when the tank was stationary, consuming about ten gallons of fuel per hour. A variety of diesel and gasoline-powered APUs were examined, including bustle-mounted gasoline and diesel APUs, and a diesel APU fitted to the left rear of the hull. However, the APU was not incorporated as a standard fitting at the time, mainly for cost reasons and this issue would crop up again once the Abrams saw extensive combat service. Some APUs were deployed on Abrams tanks during Operation *Desert Storm*.



The main ammunition stowage in the M1A1 Abrams is in the bustle behind two sliding blast doors. This view of a loader in action shows the left door still in the open position. The loader is handling an M865 120mm TPCSDS-T (target practice, core stabilized, discarding-sabot-tracer), used to simulate the M829A1 combat round during training. (US Army)

The M1E1 was type classified as the 120mm Gun Tank M1A1 in December 1984 and the first production tanks were delivered in August 1985. Priority for the new version went to the US Army Europe (USAREUR), which began receiving them in large numbers by 1988. Further evolution of special armor continued included a configuration using depleted uranium, that is, metallic uranium consisting of isotopes emitting little or no radiation. The principal advantage of uranium is its weight and density, about double that of lead per volume. Depleted uranium was employed in the third generation of special armor on the M1A1, leading to a variant dubbed the M1A1 HA (heavy armor). Besides being incorporated into new production tanks starting in October 1988, the heavy armor package could also be retrofitted to existing IPM1 and M1A1 tanks. The M1A1 and M1A1 HA were the principal types of Abrams used in the 1991 war with Iraq.

The US Marine Corps decided to adopt the M1A1 as its next main battle tank. Some modifications were necessary, most notably adaptations to permit the attachment of Deep Water Fording Kits (DWFK) to allow the tanks to be landed offshore from landing craft. These adapters did not materially affect the tank in any way and were not particularly expensive. As a result, the Army decided to incorporate these features on the production line for both Army and Marine tanks. The resulting variant was sometimes called the M1A1 CT (common tank); Marine tanks with the heavy armor package were dubbed M1A1 Heavy Common. Marine Corps procurement was funded in FY90–91 with a total of 215 tanks. This number later increased to 445 tanks due to transfers from the US Army.

Total US M1A1 production including the US Army procurement, 58 M1A1 tanks funded by the National Guard, and 215 M1A1 common tanks funded by the US Marine Corps, totaled 4,771 tanks. Some reports list other totals depending on whether pilots and pre-production test vehicles are included. The last new production M1A1 was delivered on April 28,

1993. Combined with the 62 M1A2 tanks described below, this brought total US Abrams production to 8,101 tanks. Production of new tanks for export continued through 2000, reaching a total of 9,748 Abrams tanks, of which 6,306 were produced at Lima and 3,442 at Detroit.

OPERATION *DESERT STORM*

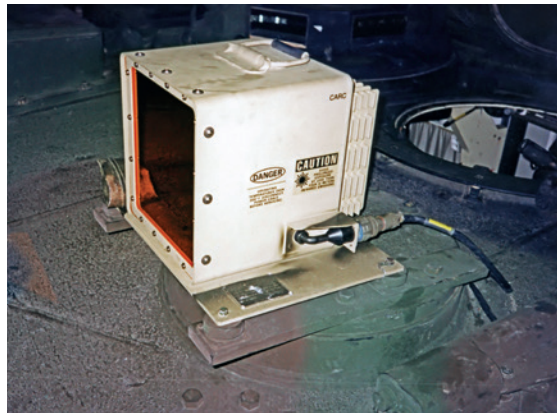
In response to Iraq's invasion of Kuwait in 1990, the United States formed a coalition to eject the Iraqi Army from that country. This led to the first combat deployment of the M1 Abrams tank. The first M1 Abrams battalions to arrive in Saudi Arabia in 1990 were part of the 24th Infantry Division (Mechanized) which still had older M1 and IPM1 tanks. As the likelihood of ground war increased, the army re-equipped as many units as possible with the M1A1, preferably the latest M1A1 HA version. Since there were not enough M1A1 HA available, a retrofit program was begun to upgrade M1A1 tanks with the heavy armor package; a total of 835 of these upgrades were completed, and they also included fire control upgrades, an NBC system heat exchanger, repainting with the CARC Tan desert camouflage paint, and a number of other improvements. As a result, only two Army battalions still had the M1 tank at the time of the start of the ground campaign. By February 1991, the US Army had deployed 1,966 M1A1 tanks to Saudi Arabia (733 M1A1, 1,233 M1A1HA), plus 528 other tanks in war reserve stock not attached to combat units. Other upgrades were applied to the M1A1 fleet in the months prior to the fighting, including the dispatch of the improved T-158 track.

The US Marine Corps (USMC) tank battalions in Operation *Desert Storm* were equipped primarily with the older M60A1 RISE/Passive tank, amounting to 277 of the 353 tanks deployed. The Marine 2nd Tank Battalion was equipped with the M1A1 HA transferred from the Army, while the two companies of the Marine Reserve 4th Tank Battalion had the new M1A1 Common Tank. In total, the USMC deployed 76 M1A1 tanks in Operation *Desert Storm*, consisting of 60 M1A1HA and 16 M1A1 Common tanks.



The US Army began acquiring the Track-Width Mine Plow before Operation *Desert Storm* to deal with the extensive border fortifications in Iraq. This is an M1A1 tank of the 24th Infantry Division (Mechanized) at Fort Stewart, Georgia, shortly after their return from the Gulf War in 1991. (Author)

The use of the M1A1 Abrams tank in Operation *Desert Storm* is covered in more detail in a previous Osprey book.[2] In general, the M1A1 Abrams dominated its best Iraqi competitor, the T-72M tank, in all technical respects, and inflicted grossly disproportionate casualties on opposing Iraqi tank units. This was not due only to technological differences, but also to operational conditions, crew training, and many other factors. It should also be noted that the T-72M used by the Iraqi Army was a Soviet/Warsaw Pact export version with inferior armor, fire controls, and ammunition compared to the forward-deployed Soviet tank units.



The US Army developed a Missile Countermeasure Device (MCD) as a soft-kill protection system against antitank missiles using electro-optical jamming. This is a Loral AN/VLQ-6 fitted on a Marine M1A1. The similar Sanders AN/VLQ-8A MCD was acquired at the same time as an urgent requirement prior to Operation *Desert Storm*. They were usually mounted on the circular CITV plate in front of the loader. (Author)

The US government watchdog agency, the GAO (Government Accounting Office), issued a performance assessment after the conflict that concluded that:

> During the war, the Abrams tank exhibited good reliability, lethality, survivability, and mobility, but limited range… Reported Army readiness rates were 90 percent or higher during the ground war – indicating a high availability to move, shoot, and communicate during combat. The Abrams was lethal, as crews said its 120mm gun was accurate and its ammunition deadly against all forms of Iraqi armor. Army observers attribute the gun's high degree of accuracy to superior sights, high levels of tank readiness, and soldier training. The Abrams also survived well on the battlefield. For example … several M1A1 crews reported receiving direct frontal hits from Iraqi T-72s with minimal damage… Crews said the Abrams tanks were fast and maneuvered well in the sand. Abrams crews were impressed with the power and performance of the Abrams' turbine engine, but they were concerned about its high fuel consumption and the need to frequently clean air filters in the sandy desert environment. Refueling was a constant concern, and faulty fuel pumps further compounded the problem. The harsh desert environment demanded frequent air filter cleaning because sand-clogged filters reduced engine power and speed. In extreme cases, sand damaged engines. Army officials are aware of the problems with high fuel consumption, unreliable fuel pumps, and sand ingestion. They are working on solutions to improve fuel economy, fuel pump design, and the air filtration system. Abrams crews also identified other desired tank improvements, including better sight magnification and resolution and the addition of an identification of friend or foe system, a turret/hull reference indicator, and driver's and commander's thermal viewers. Army officials said these and other enhancements were being considered for future Abrams improvements.

A total of 23 Abrams tanks were destroyed or heavily damaged during the conflict, a remarkably low number. Of the nine destroyed Abrams, seven were due to friendly fire and two were destroyed by their crews after they became disabled to prevent their capture. There is some dispute about the number of Abrams damaged by Iraqi fire and the extent of the damage.

2 Steven Zaloga, *M1 Abrams vs. T-72 Ural: Operation Desert Storm 1991*, Duel 18 (Osprey, 2009).



An M1A2 of G Troop, 1-16th Cavalry at the Fort Knox Armor Center in May 2002, in the standard "Europe 1" camouflage based on the NATO 3-color scheme. The distinctive feature of the M1A2 was the CITV, located in front of the loader's station on the left front side of the turret. Although not evident from this view, this tank was upgraded to the M1A2 SEP configuration with the Thermal Management System and Under Armor APU. (Author)

THE M1A2

The next stage of Abrams tank development was the M1A1E1 Block 2. This was intended to incorporate the CITV, an improved commander's weapon station (ICWS), a position/navigation (PosNav) system, and a digital electronically integrated information system. Full-scale engineering development for a "fiscally constrained" tank was approved by OSD on October 18, 1989, and the contract included the construction of ten prototype and five pilot production tanks. The initial requirement was for 2,926 M1A2 tanks. In April 1990, the Army decided to begin acquisition by completing the last 62 M1A1 tanks funded in FY91 as M1A2 tanks. After Congressional permission, this was approved in May 1992. In the event, this would be the only serial production M1A2 tanks acquired by the Army. The M1A2 was type classified in April 1994.

The collapse of the Soviet Union in 1991 had a dramatic impact on the Army tank program. On May 20, 1992, Donald Yockey, the Undersecretary of Defense for Acquisition, stated that, "There are enough tanks available now to meet any perceived contingency and there is enough time to reconstitute the tank industrial base if a global threat emerges. Therefore, tank production will cease as planned."

As a result of the OSD decision, no further new tank production for the US Army was funded after FY92, when a final batch of 18 tanks were acquired as part of a Gulf War supplemental funding package. The last of the US Army's production series M1A2 tanks was delivered in 1995.

With the end of the Cold War, there was some confusion over the direction that the tank program should take. Congress began to pressure the Army to shift from new production to an upgrade/modification program to rebuild older M1 tanks into the M1A2 configuration. This was intended to keep the industrial base warm in the event that it was necessary to restart production. In addition, in July 1990, the US government agreed to sell M1A2 tanks to Saudi Arabia and there was some interest in keeping at least one factory open for potential export clients. In the event, the Detroit Army Tank Plant ended Abrams production in 1991 so the Lima Army Tank Plant remained in use.



An M1A1 AIM of 37th Armor, 1st Armored Division during exercise *Ready Crucible* in Germany, on February 11, 2005. This shows the usual configuration of the Combat Identification Panels (CIP) in use since Operation *Desert Storm* with the venetian style on the sides and the flat panels on the front. One side of the panel has a low emissivity thermal coating and on the other side is the usual green or tan CARC paint. This tank has the panels in the "off" position with the CARC paint side exposed; the other side creates a distinct signature when viewed through thermal imaging sights. (DoD/Richard Bumgardner)

Since new production was unlikely in the short term, the Army proposed the start of an Armored Systems Modernization (ASM) program costing $59 billion. The program proposed the development and manufacture of seven armored fighting vehicles using common chassis systems. Four of these, the Block III tank, the Combat Mobility Vehicle, the Advanced Field Artillery System, and the Future Infantry Fighting Vehicle, would share a common heavy chassis. The Line-of-Sight Antitank System and the Future Armored Resupply Vehicle-Ammunition would be built on a common medium chassis and the Armored Gun System on a light chassis. The Block III, unofficially called the M1A3, was expected to be a further evolution of the Abrams tank, but armed with a more powerful 140mm gun. In the event, the price tag for the program was regarded as unsupportable in the post-Cold War environment, and ASM expired from a lack of funding.

The Abrams program was reoriented from a new production program to a modification/upgrade program in FY92. These are two distinct, separately funded programs, GA0700 (modification) and GA0750 (upgrade). The modification program was fleet-wide and included a variety of new sub-systems that could be incorporated into the M1A1 Abrams without the need for a complete reconstruction of the tank. The upgrade program focused on deeper modernization of older M1 and IPM1 tanks to the M1A2 configuration since these tanks were regarded as obsolete due to their 105mm guns and older armor packages. These programs were conducted primarily at the Lima Army Tank Plant in conjunction with the Anniston Army Depot.

M1A1 MODIFICATION PROGRAM 1990–2000

The M1A1 modification program began in 1989 even before M1A1 production had ended. The first major effort was the Armament Enhancement Initiative (AEI) which developed new types of 120mm tank gun ammunition. This included the M829A1 APFSDS round, better known as the "Silver Bullet" for its performance in Operation *Desert Storm*. Another new cartridge

was the M830A1 HEAT-MP-T. This was a replacement for the older M830 HEAT cartridge but it used an entirely reconfigured sub-caliber projectile with discarding sabot to increase its speed. The other novel feature was the incorporation of an optional anti-helicopter mode, hence the designation "MP" for multipurpose. If engaging a helicopter, the loader could activate the proximity sensor in the nose of the projectile. As a result, the projectile could engage helicopters at extended ranges without needing to score a direct hit. This cartridge was type classified after *Desert Storm* in September 1992 and was widely deployed by 1994.

Although most of the AEI program focused on the ammunition, it also required improvements on the M1A1 Abrams such as adjustments in the tank fire control system to accommodate the ballistics of the new ammunition types as well as the addition of new reticles in the sighting system. This was a continuing modification effort since several generations of new ammunition were introduced through the 1990s. Rock Island Arsenal also upgraded the first 1,630 M1A1 tanks with gun mount improvements to accommodate the higher pressures of the new ammunition. In 2004, a program began to modify tanks to use the newer M829A3 "Super Sabot" round.

One of the high priority efforts after Operation *Desert Storm* was the Pulse-Jet System (PJS) that replaced a large portion of the previous engine air filtration system. This helped extend the time between required air path servicing in severe dust environments such as the desert. These upgrades began in 1995 and were mostly completed by 2008.

Many of the improvements on the M1A1 exploited the growing capabilities of modern electronics. In 1999, the M1A1 was improved with the introduction of a Precision Lightweight GPS Receiver (PLGR). This was based on the lessons from Operation *Desert Storm* where the improvised use of hand-held GPS receivers was shown to be a revolutionary leap forward in vehicle navigation. This program continued through 2008 with about 1,325 tanks fitted with the PLGR.

In 1992, the Army started the M1A1-D (GA0720 Digitization) program. This modification was part of a broader Army digitization effort called Force XXI Battle Command Brigade and Below (FBCB2). One of the novel capabilities it offered was a pointing device incorporated into the tank's computer to provide range and elevation data necessary to engage targets beyond the crew's line of sight. This program was funded in FY01–02 to equip 1,535 M1A1 tanks.

The first step in addressing the problem of friendly fire incidents was the development of a simple Combat Identification Panel (CIP) that could be carried on tanks. This has a very distinctive signature when viewed through a thermal imaging tank sight. The next step was to take advantage of digital innovations. Blue Force Tracker (BFT) is a digital system that gives Army commanders across the battlefield current information about their location relative to friendly forces. Once the M1A1 was fitted with the PLGR, the GPS navigation/location data could be fed into the FBCB2 computer system. This emits a signal that is integrated into the BFT map display showing the precise location of all other friendly forces equipped with BFT. The BFT was installed on M1A1 tanks starting in 2005. In 2013, this was followed by BFT-2 which uses modernized transceivers to improve the speed and "refresh" time of the network. BFT-2 is part of a larger program called Joint

Battle Command-Platform (JBC-P) that adds next-generation mapping, chat, and messaging capability, and an improved graphical interface as well as expanding the network to include a wider range of BFT devices with infantry, armor, and other combat units.

The growing use of electronics on tanks also created increased electrical power demands. After much debate, in 1991–94 the Army added External Auxiliary Power Units (EAPU) to 1,500 M1A1 tanks to avoid the need to run the main gas-turbine engine for electrical power when in stationary Silent Watch Mode. The EAPU provides power for ten to 12 hours on one tank of diesel fuel. The Army decided to wait for an Under Armor APU (UAAPU) for the new M1A2 SEP (System Enhancement Program). Congress disagreed and funded a short-term modification effort. As a result, in 1997, 336 M1A2 tanks had EAPUs mounted in the left side of the turret bustle rack.

In 1998, a program was begun to incorporate improved turret side armor into the M1A2. This was intended to offer better protection against rocket-propelled grenades more modern than the baseline RPG-7. These kits were installed on about 325 older M1A2 tanks in 2001–09 and it was also included in upgraded tanks.

In 1999, a program began to replace the existing laser range finders with eye-safe laser range finders (ELRF). This was done since stringent safety precautions had to be taken during peacetime training with the older lasers because they could cause eye damage. About 3,200 M1A1 and M1A2 tanks were modified with this device through 2009.

By the late 1990s, portions of the M1A1 fleet were becoming mechanically exhausted, leading to increased maintenance costs. The Abrams Integrated Management Program for the 21st Century (AIM XXI) was initiated to deal with tanks that were not earmarked for the M1A2 upgrade. The M1A1 tanks were completely disassembled at the Anniston Army Depot and then overhauled by GDLS at the Lima Army Tank Plant. The first of the M1A1 (AIM) tanks were delivered in July 2000, and by 2004 about 135 tanks went through the AIM process annually. Once the program was underway, the AIM program became the venue for the various modifications for the M1A1 force.

M1A2 UPGRADE PROGRAM

The decision to halt further new Abrams tank production, plus the availability of a large pool of older M1 and IPM1 tanks, led the OSD on December 18, 1992, to approve a program to upgrade 998 M1 tanks into the M1A2 configuration starting in 1993. The first upgraded M1A2 was delivered in October 1994 and the first unit equipped was the 3rd Squadron, 8th Cavalry at Fort Hood, Texas. The upgraded tanks received the CITV, Improved Commander's Weapon Station, position/navigation equipment, improved armor, and other features.

While the basic upgrade process was underway, the Army also began the first steps towards a SEP aimed at the M1A2 fleet. The main focus of this program was to improve the computer core of the M1A2 so that it could be employed in an all-digital division. The SEP included the improved FBCB2 digital command and control system, second-generation "Block 0" thermal imaging systems, a computer memory upgrade, color map displays, and



An M1A2 SEP from the 2nd Battalion, 7th Cavalry Regiment, 3rd Armored Combat Team, 1st Cavalry Division participates in a field training exercise during *Bright Star 2017*, on September 15, 2017, at Mohamed Naguib Military Base, Egypt. This tank had the Thermal Management System in the rear bustle, and has some elements from the TUSK kit such as the loader's armor shield. (US Air Force/Staff Sgt Michael Battles)

other features. The second-generation HTI-SGF thermal imaging system replaced the existing sensors in the Gunner's Primary Sight and Commander's Independent Thermal Viewer with new-generation technology that offered substantially better image quality. This entered production in the baseline "Block 0" configuration in 1997 and first entered service in 1999.

As mentioned above, the M1A2 SEP upgrade was intended to incorporate a UAAPU, located in the upper left corner of the rear engine compartment, replacing the previous 55-gallon fuel cell. One of the reasons for locating the UAAPU in the hull was the need to find space for the Thermal Management System (TMS) which was added to the M1A2 SEP. The TMS Model 3212, provided by Meggitt Defense Systems, was designed to remove excess heat produced by the increasing volume of electronics in the turret. The most visible element of the TMS was a vapor compression system unit (VCSU) that was mounted on the left turret rear in the turret bustle where the EAPU had previously been located. In the event, the UAAPU for the M1A2 SEP proved to be unreliable, and it was replaced after 2005 with the battery-based Alternate APU (AAPU). The new Hawker batteries employed absorbed-glass-mat (AGM) battery technology instead of the older flooded-cell lead-acid technology.

The first M1A2 SEP was delivered in September 1999 and the first unit equipped was a company in the 4th Infantry Division (Mechanized) at Fort Hood in May 2000. The M1A2 SEP was also deployed with the 1st Cavalry Division. The M1A2 SEP program was later extended by a separately funded program, GA0730, to retrofit the existing fleet of M1A2 tanks to the M1A2 SEP standards, with funding from FY01 to FY09 for 319 upgraded M1A2 tanks.

In September 2000, the Army awarded a team of General Electric and Honeywell to develop their LV-100-5 gas-turbine engine as the Abrams-Crusader Common Engine (ACCE). The plan was to use this more modern engine to replace the older AGT-1500 in the Abrams, as well as to power the new XM2001 Crusader 155mm self-propelled gun. In the event, the cancelation of the Crusader program in May 2002 put an end to the new engine program. In its place, the Army initiated the TIGER (Total Integrated Engine Revitalization) program which aimed to completely rebuild the existing engines to the equivalent of brand new engines. At the IDEF-97 show in Ankara in 1997, GDLS offered the Turkish Army a version of the M1A2 using the German EuroPowerPack diesel engine. In the event, Turkey selected the Leopard 2 tank.

BACK TO WAR: 2003–15

At the time of the Second Gulf War in 2003, the active US Army Abrams fleet numbered about 2,340 tanks, with about 1,510 tanks deployed with armor battalions and cavalry squadrons and 700 more in pre-positioned stocks around the globe. There were also over 3,000 Abrams tanks in storage. Of the divisions assigned to the Counter Attack Corps, the 1st Cavalry Division and 4th Infantry Division were converting to the M1A2 SEP, the 3rd Armored Cavalry to the M1A1 AIM, and the 3rd Infantry Division to the M1A1.

Operation *Iraqi Freedom* (OIF) began on March 19, 2003, aimed at overthrowing the Baathist regime of Saddam Hussein. The ground portion of the conflict was spearheaded by the US Army V Corps with the 3rd Infantry Division as its primary mechanized force. The 3rd Infantry Division had 247 M1A1 Abrams tanks at the start of the conflict. While this force advanced on Baghdad from Kuwait, the 1st Marine Expeditionary Force advanced on its right flank, including two tank battalions with 116 M1A1 tanks. The 4th Infantry Division, equipped with the newer M1A2 SEP tanks, was intended to operate from Turkey against northern Iraq but, in the event, permission was refused by the Turkish government. It eventually moved into Iraq after the initial attack. The Iraqi Army had not been significantly reconstituted since Operation *Desert Storm*, and the campaign was concluded in a month and a half by early May 2003. Several Abrams tanks were destroyed or damaged during the campaign, primarily by infantry antitank weapons and not Iraqi tanks.

In contrast to the first Gulf War, the US Army remained on occupation duty in Iraq subsequent to the conflict. Instead of a conventional conflict, the situation gradually deteriorated into a violent civil war and insurgency. Tanks were not a central feature of US Army counter-insurgency doctrine, but Abrams tanks remained in Iraq and were used in a variety of missions in support of counter-insurgency operations. By early 2005, about 80 Abrams tanks had been damaged, primarily due to mine, IED, and rocket attacks, and were sent back to the United States for repair. As of 2009, there were about 410 Abrams deployed in Iraq.



A pair of M1A1 AIM tanks of Company A, 1-35th Armor, 2nd BCT, 1st Armored Division pose under the Hands of Victory monument in Ceremony Square, Baghdad, during Operation *Iraqi Freedom* on November 13, 2003. (USAF/TSgt John Houghton Jr)



A Marine Corps M1A1 Abrams of the Marine 2nd Tank Battalion fires its main gun into a building to provide suppressive counterfire against insurgents during a fire fight in Fallujah, Al Anbar Province, Iraq, on December 10, 2004. This tank is fitted with one of the USMC Bustle Rack Extensions on the rear of the turret. (US Marine Corps/Lance Corporal James J. Vooris)

The counter-insurgency campaign led to an urgent requirement for an anti-personnel projectile for the 120mm gun. General Dynamics developed the M1028 cannister round on a crash basis. This projectile contains 1,000 tungsten balls that spray out in a wide arc. The projectile was also designed so that it could carry less-lethal payloads as an alternative, such as rubber balls or "flash-bang" stun charges. This cartridge was type classified in December 2004. Although developed prior to the Iraq campaign, the M908 120mm obstacle reduction round saw its combat debut there. This was a specialized high explosive round specifically designed to attack bunkers or concrete obstacles.

There were a number of other improvements added to the Abrams during the course of the fighting. One visible change was the development of a Bustle Rack Extension (BRE) by the Marine Corps. This was necessary in part since the original bustle rack was gradually fitted with permanent equipment such as the EAPU, limiting the amount of exterior stowage.

One of the emerging threats from the insurgent forces was the use of remotely detonated roadside bombs, usually categorized as IEDs (Improvised Explosive Devices). These varied in size from small anti-personnel mines through massive road mines based on artillery projectiles and even aircraft bombs. To address the IED threat, there were several modification programs for the Abrams fleet. One approach was the development of IED jammers. Many of the IEDs were remotely detonated using radio-based devices such as garage door openers. Jammers were developed that could detonate the IED away from US troops, or jam the frequency to prevent detonation. This program was not unique to the Abrams tank effort, but part of a

B

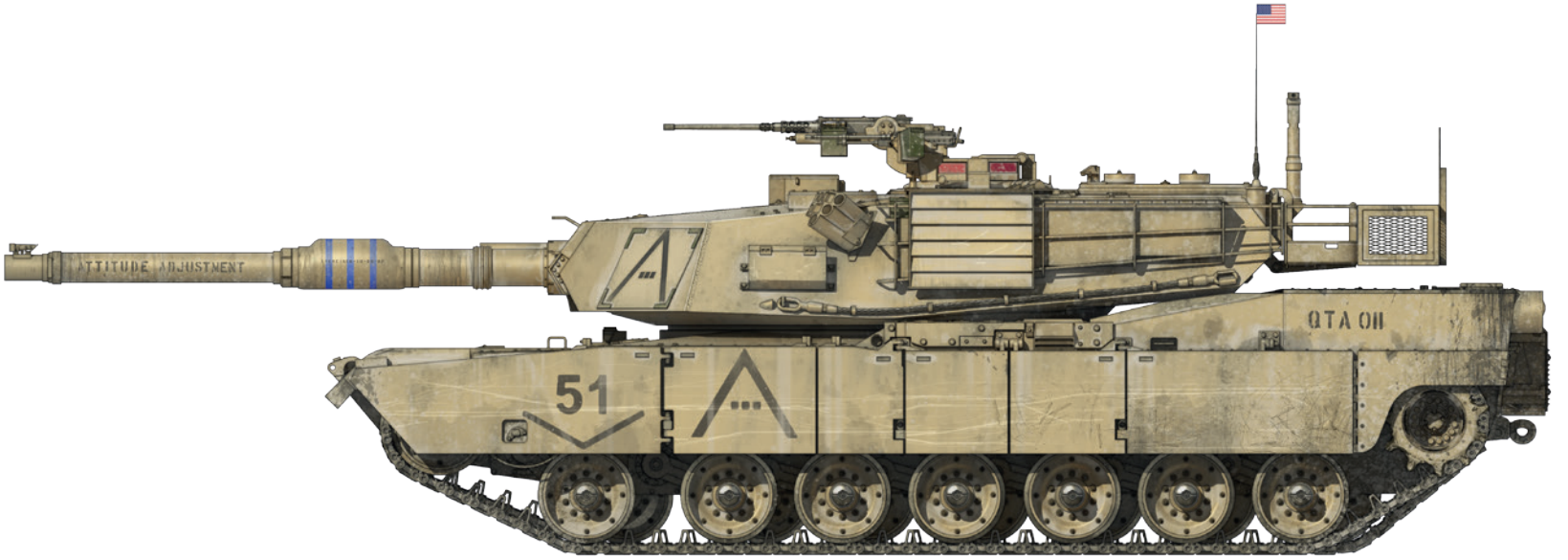
M1A1 AIM, 3rd PLATOON, COMPANY A, TASK FORCE 1-64 ARMOR, 2nd BRIGADE, 3rd INFANTRY DIVISION (MECHANIZED), OPERATION *IRAQI FREEDOM*, MARCH 2003

Most US Army vehicles in Operation *Iraqi Freedom* were painted in CARC Tan 686A. The color corresponds to Federal Standard FS 33446.

The 3rd Infantry Division used a complicated set of markings to distinguish sub-formations. The 1-64 Armor used two-digit numbers in the 50 series with the headquarters company identified by 50, A Company by 51, B Company by 52, and C Company by 53. These numbers were painted in the center of a chevron, with the direction indicating the platoon: upwards (1st platoon), right (2nd), down (3rd). This marking was painted on the side skirts, on the front CIP (Combat Identification Panels) and on a "Battle-board" attached to the left of the bustle extension rack.

This divisional system was accompanied by a system peculiar to the 64th Armor that consisted of a chevron with a set of square dots inside that indicated the platoon. The direction of the chevron indicated the tank company: upward (A), down (B), left (C), and right (D). Gun barrel rings were in platoon colors: red (1st), white (2nd), and blue (3rd). The number of rings indicated the tank within the platoon, so three blue rings indicated Tank 3 in the 3rd platoon. The tank names, painted on the gun barrel, followed the traditional practice of starting with the company letter, in this case "A."

The usual bumper codes were carried front and rear, in this case TF 1-64^ for Task Force 1-64 Armor, and A-33 for 3rd Tank, 3rd Platoon, Company A. There were some large stenciled transport markings painted on the front and rear as well.


ATTITUDE ADJUSTMENT
51
QTA OII


QTA OII
A 9049 ARM BN


51
TF
64
QTA OII
A33



A combat patrol of M1A2 tanks of the 3rd Armored Cavalry Regiment in Tal Afar, Iraq, on February 3, 2005. This tank is fitted with the Loader's Armor Gun Shield (LAGS), but not the full TUSK kit. (US DoD/Staff Sgt Aaron Allmon, USAF)

broader effort. One of the more common types fitted to the Abrams was the AN/VLQ-12 Duke system.

The most elaborate effort was TUSK (Tank Urban Survivability Kit). This was designed to address several threats encountered in Iraq. GDLS was awarded a contract for the first batch of 505 TUSK kits in August 2006, with further kits purchased in later years. The TUSK upgrade was an appliqué that could be attached to any of the current versions of the M1A1 and M1A2.

Although the Abrams frontal armor was largely proof against insurgent rocket-propelled grenades (RPG), the sides were more vulnerable. A new threat appeared in the form of an off-route mine developed in Iran that used an EFP (explosively formed penetrator) warhead. To address this threat, the TUSK included a set of ARAT (Abrams Reactive Armor Tiles). The basic ARAT 1 kit consisted of 32 XM19 boxes on each side of the tank. The more



An M1A1 tank of Delta Company, Marine 2nd Tank Battalion during an operation in Helmand province, Afghanistan, on September 7, 2013. The exhaust plenum for the deep water fording kit peculiar to Marine tanks can be seen in the center of the rear exhaust grill. The two cylindrical antennae are associated with the AN/VLQ-12 CREW (Counter Remote Controlled Improvised Explosive Device [RCIED] Electronic Warfare) system. (US Marine Corps/Cpl Trent A. Randolph)

elaborate TUSK II configuration added the XM32 ARAT II tiles. These are rounded panels and 32 are attached over the XM19 boxes on the hull sides as well as 11 more to the turret sides. These explosive reactive armor tiles added over three tons to the tank's overall weight and so were generally not fitted to tanks unless in a war zone. To deal with the mine threat, TUSK also included a two-ton belly armor kit which attached under the crew compartment. Vehicle seats were also modified to reduce crew injuries during IED explosions by providing shock absorption features.

Abrams' loaders operating the external M240 machine gun were vulnerable to snipers, so a Loader's Armor Gun Shield (LAGS) was added that offers ballistic protection while at the same time offering forward vision through a transparent armor gun shield (TAGS). The loader was also provided with a Loader's Thermal Weapon Sight (LTWS) for night vision which has an associated helmet-mounted display for more convenient use. The tank commander received a similar Commander's Bolt-On Armor Kit.



These are three of the new 120mm rounds developed in the early 2000s. From left to right they are the M829A3 APFSDS, M830A1 HEAT-MP, and M1028 120mm cannister round. (Author)

The tank's main gun is often excessive for engaging snipers in an urban environment, so the US Army took a cue from Israeli practices and mounted a .50cal heavy machine gun over the main gun on a Counter-Sniper/Anti Materiel Mount (CSAMM).

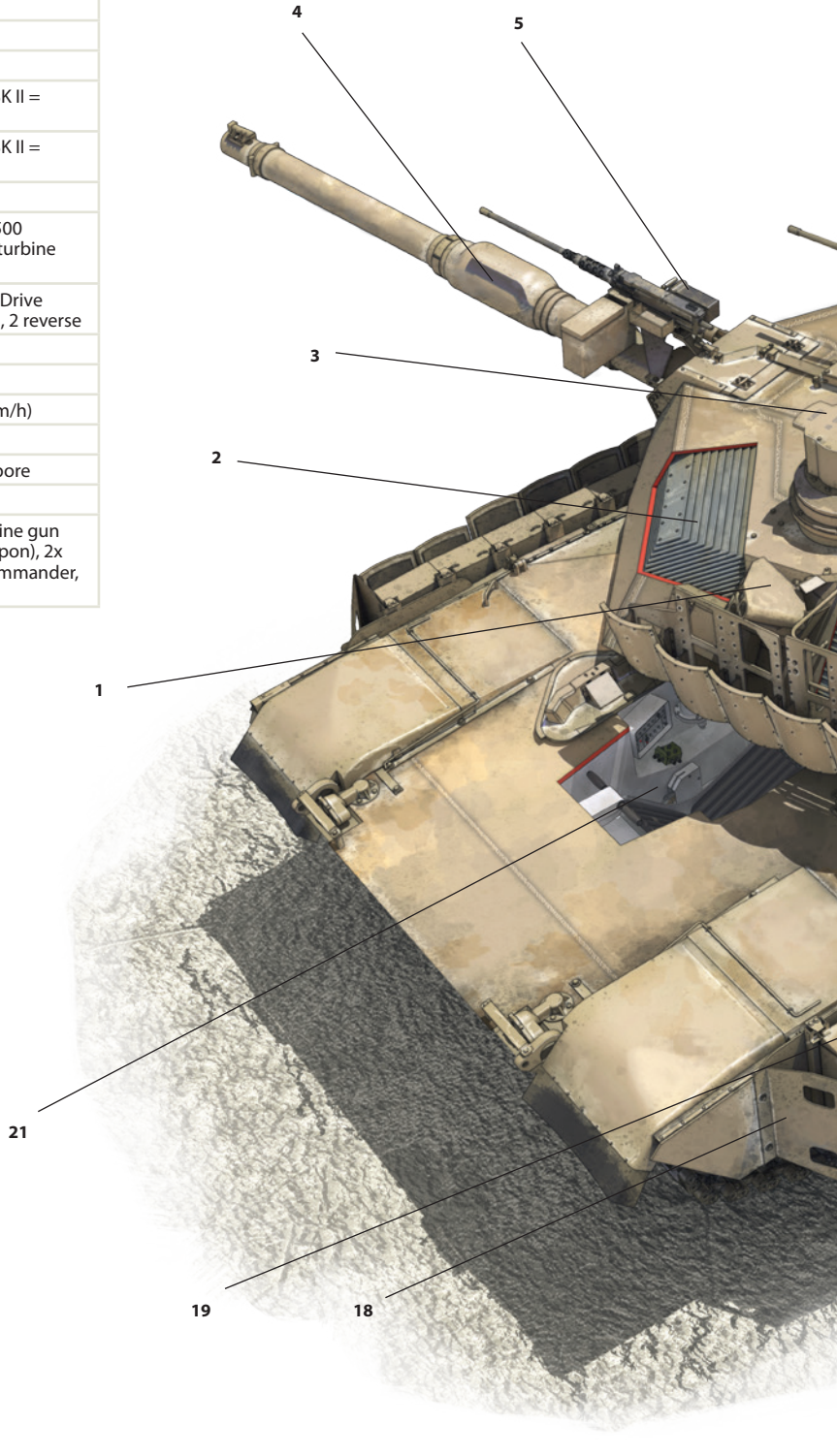
Other features added as part of the TUSK program included a tank-infantry phone to allow accompanying infantry to communicate with the tank crew. The driver was also provided with an AN/VAS-5 Driver's Vision Enhancer, a thermal night sight permitting night and all-weather vision. M1A1 tanks fitted with TUSK also received a Remote Thermal Sight on the commander's station to allow engagement of urban targets at night with the .50cal machine gun with the hatch closed.



An M1A1 AIM fitted with a mine-clearing roller of Company B, 1st Battalion, 35th Armor Regiment, Task Force 4-27 "Thunder," 2nd Brigade Combat Team, 1st Armored Division clears fields in the Jabour area, south of Baghdad, on December 15, 2008. This tank is fitted with the basic TUSK kit including the XM19 ARAT reactive armor. (US Army/ Staff Sgt Scott Wolfe)

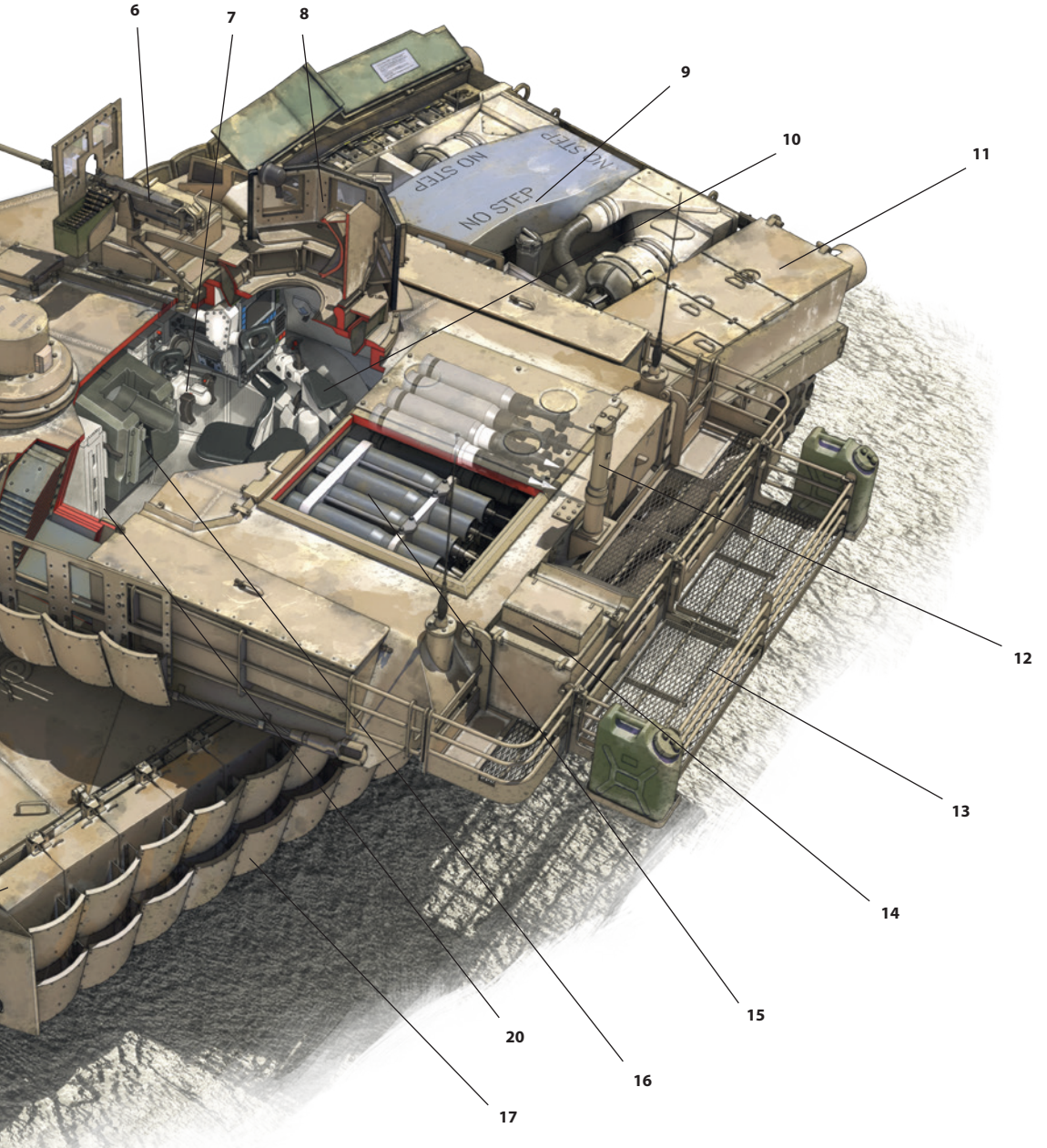
C M1A2 SEP WITH TUSK II

Technical Data	
Crew	4 (commander, gunner, loader, driver)
Combat Weight	68 tons (61 tonnes); with TUSK II kit +5.5 tons
Ground Pressure	15.5 psi (1.09 kg/cm^2)
Length, Overall	32.25ft (9.83m)
Width, Overall	12.0ft (3.66m); with TUSK II = 14.2ft (4.34m)
Height, Overall	9.47ft (2.89m); with TUSK II = 9.7ft (2.95m)
Height, Turret Top	7.79ft (2.37m)
Engine	AVCO Lycoming AGT-1500 1,500hp (1,119kw) gas-turbine engine
Transmission	Allison X1100-3B Cross-Drive Transmission. 4 forward, 2 reverse
Range	298 miles (479km)
Fuel Capacity	504.4 gal (1,909 ltr)
Road Speed	42mph, governed (67km/h)
Cross-Country Speed	30mph (48km/h)
Main gun	120mm M256 smooth bore
Main gun ammunition	42 rounds
Secondary armament	2x 7.62mm M240 machine gun (co-axial + loader's weapon), 2x .50cal machine gun (commander, counter-sniper mount)



KEY

1. Smoke grenade discharger
2. Layered armor
3. Commander's Independent Thermal Viewer (CITV)
4. Bore evacuator for 120mm M256 gun
5. Counter-Sniper/Anti-Materiel Mount (CSAMM)
6. Commander's .50cal heavy machine gun
7. Gunner's station
8. Commander's Bolt-On Armor Kit
9. AGT-1500 gas-turbine engine
10. Commander's station
11. Alternate Auxiliary Power Unit (AAPU)
12. Tank Crosswind Sensor
13. Bustle Rack Extension (BRE)
14. Vapor Compression System Unit (VCSU) for Thermal Management System
15. 120mm ammunition stowage
16. 120mm M256 gun breech
17. XM32 ARAT II reactive armor tiles
18. Brush guard for reactive armor
19. XM19 ARAT I reactive armor tiles
20. Loader's station
21. Driver's station





The TUSK II kit includes a second layer of curved XM32 ARAT reactive armor tiles over the XM19 ARAT boxes. This is an M1A2 SEPv2 assigned to the 1st Battalion, 66th Armor Regiment, 3rd Armor Brigade Combat Team, 4th Infantry Division, at Grafenwoehr Training Area, Germany, on February 28, 2017. (US Army/ Gerhard Seuffert)

FIREPOWER ENHANCEMENTS

The US Army examined a succession of guided 120mm projectiles in the 1990s, primarily aimed at extending the effective range of the Abrams gun. The XM943 STAFF (Smart Target Activated Fire & Forget) was a 120mm projectile using an active millimeter-wave radar for terminal guidance. Proof-of-principle tests concluded in 1998 without a satisfactory design. In parallel, the army was also developing the XM1007 TERM-KE (Tank Extended Range Munition-Kinetic Energy) that examined guidance methods for a kinetic energy penetrator as an alternative to the high explosive shaped-charge warhead on the STAFF. Although development continued for several years beyond the STAFF, the program never reached production.

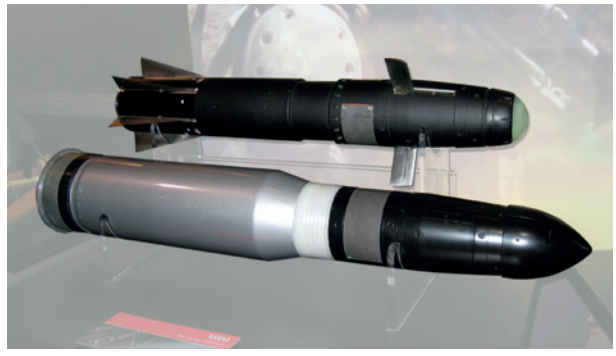
The next effort was the XM1111 MRM (Medium Range Munition) which was developed both for the Abrams as well as the Future Combat System (FCS). The MRM was designed as a beyond-line-of-sight projectile that could take advantage of the innovations in GPS-based navigation technology on the tank to aim the projectile roughly into the target area, after which an onboard sensor would correct the terminal flight path prior to impact. After studying several competing designs, in January 2008, the Army selected a Raytheon/General Dynamics Ordnance design for engineering development with plans to reach production in 2012. The MRM design was in effect a tube-fired missile with the projectile using an inertial measurement unit in the initial stage of flight into the target area, followed by optional precision attack modes. In an autonomous mode, the projectile relied on an imaging infrared sensor to locate the target. Alternately, it could use a semi-active laser seeker with the laser designation coming from the tank or from an independent designator such as an artillery forward observer. In March 2007, a test MRM struck a T-72 tank at a range of 3 miles at Yuma Proving Ground. In the event, the MRM program was canceled in 2010 in connection with the termination of the Future Combat System.

M1A1 SA

Due to the accelerated mechanical exhaustion of Abrams tanks during the Iraq war, in 2004 the US Army instituted a “Reset” program to address the condition of equipment. This placed increased emphasis on reducing the operating costs of the Abrams tank, especially the AGT-1500 engine. As mentioned earlier, the TIGER engine overhaul program was developed by Honeywell and the Anniston Army Depot.

Since it appeared that the M1A1 would remain in the Abrams fleet indefinitely, a RECAP (Recapitalization) program was incorporated into the existing M1A1 AIM modification program. A package of improvements was consolidated into the M1A1 SA (Situational Awareness) program. Many of these improvements had already been applied to the M1A2 as part of the SEP effort. The M1A1 SA included the Raytheon Block 1 second-generation

thermal imaging system and a range of other upgrades, including Blue Force Tracker (BFT), FBCB2, eye-safe laser range finder, the remote thermal sight on the commander's station, the tank-infantry phone, and Far Target Locate (FTL) capability. FTL was a Marine Corps initiative to integrate the data from the laser range finder and tank position/navigation system to provide accurate target location out to 8,000 meters for engagement by the tank's main gun or to hand-off to the field artillery or supporting aircraft. The M1A1 SA also included the TIGER engine upgrade, front and side armor upgrades, and a host of small safety and maintenance improvements. The first 155 M1A1 SA tank packages were acquired under an August 2006 contract to GDLS. The next step in this program was the M1A1 SA/ED, which added an embedded diagnostics system. A pilot of this version was completed at Anniston Army Depot in January 2008 and the first was delivered in March 2009. The M1A1 SA tanks were delivered to the 1st Infantry Division, 2nd Infantry Division, Army National Guard units, and pre-positioned stocks in Kuwait and Korea. By late 2009, the US Army's Heavy Brigade Combat Teams deployed 2,505 Abrams tanks consisting of 958 M1A1 SA and 1,547 M1A2 SEP. In 2015, the Army Abrams fleet included 791 M1A1 SA and 1,593 M1A2 SEP tanks.



The XM1111 Medium Range Munition was an attempt to develop a long-range guided projectile for the 120mm gun. This photo shows the complete round below and the projectile itself above with the protective nose shroud discarded and the guidance fins extended. (Author)

In recent years, the active Army Heavy Brigade Combat Teams have been consolidating around the M1A2 SEP, while the Army National Guard ABCTs (Armored Brigade Combat Teams) field both the M1A2 SEP and M1A1 SA. The Heavy Brigade Combat Teams (HBCT) are a combined arms formation that include 60 Abrams, 93 Bradley infantry/cavalry fighting vehicles, and 17 M109A6 Paladins. In 2009, there were 31 HBCTs consisting of 19 active, seven reserve, three pre-positioned stock, and two equipping force pool units.



Over the past decade, the M1A2 SEP became the predominant version in active Army HBCT. The M1A1 SA remained in the National Guard ABCT. This is an M1A1 SA of the South Carolina Army National Guard participating in a Combined Arms Demonstration at McEntire Joint National Guard Base, South Carolina, on May 5, 2017, with an AH-64 Apache helicopter overhead. (US Army National Guard/Sgt Tashera Pravato)

THE POST-OIF M1A2 ABRAMS UPGRADES

The withdrawal of the US Army from Iraq began in December 2007 and was completed by December 2011. Modernization of the Abrams fleet had stagnated during this period except for those aspects of the program connected with operations there such as the TUSK. Aside from war costs, the heavy drain of US Army funding into the misbegotten Future Combat System program was the most critical impediment to Abrams modernization, since it was presumed that the Army would be converting to a new generation of heavy combat vehicles in the decade ahead. In April 2009, the Secretary of Defense canceled the Future Combat System program before even a single prototype of the XM1202 Mounted Combat System had been built. This meant that the M1A2 Abrams would remain the core of the Army tank force for the foreseeable future.

The next stage in M1A2 evolution was the M1A2 SEPv2. The most visible change on this version was the addition of an M153A1E1 CROWS-LP (Common Remotely Operated Weapon Station-Low Profile) in front of the commander's station. This system allows the .50cal machine gun to be remotely aimed and fired by the commander from within the tank. On March 21, 2016, Gen Robert Abrams, commander of US Army Forces Command, instructed that the Army should immediately stop the fielding of CROWS-LP since the system did not correct tank commander visual and fire control issues. As a result, the M1A2 SEPv2 reverted back to the earlier Flex Mount machine gun on the commander's station. Tanks already fitted with the CROWS-LP retained them for several years.

Most of the changes in the M1A2 SEPv2 were internal. The fire control system was upgraded to permit the use of the new M829A3 APFSDS projectile and M1028 cannister projectile. Digital improvements continued, including improved microprocessors and memory upgrades, new color flat-panel displays, and the new Common Operating Environment (COE) computer operating system. The Gunner Primary Sight and Commander's Independent Thermal Imaging Sight both were upgraded from the Block 0 to the Block 1 HTI-SGF second-generational thermal imaging technology. Both frontal and side armor were improved. The M1A2 SEPv2 incorporated the TIGER engine, a battery-based auxiliary power unit, and an upgraded transmission.

GDLS was awarded a contract in February 2008 to upgrade 435 M1A1 tanks to the M1A2 SEPv2 configuration. The 4th Brigade, 1st Cavalry Division was the first unit equipped with the M1A2 SEPv2. Deliveries in 2009–10 subsequently included the 1st Brigade, 1st Armored Division, and the 4th Infantry Division. In 2011–12, deliveries were extended to the 2nd Infantry Division and 3rd Infantry Division. The M1A2 SEPv2 was also deployed with the Army National Guard (ARNG), including the 115th Armored Brigade Combat Team (Mississippi ARNG), 116th ABCT (Idaho ARNG), and the 2-137th Combined Arms Battalion (Kansas ARNG). Production of the M1A2 SEPv2 for the US Army concluded in January 2017.

Continuing M1A2 SEP improvements were outlined in a set of Engineering Change Proposals (ECP) that were approved in June 2011. ECP 1A (Power) included an updated Handheld Manpack Small (HMS) communication system, a new 1,000-amp generator, an updated power management distribution system, the integration of the CREW/Duke 3 IED jammer, Next



M1A2 SEPv2 Abrams tanks of Company C, 2nd Battalion, 5th Cavalry Regiment, 1st Brigade Combat Team, 1st Cavalry Division, take part in the *Combined Resolve II* maneuvers at Hohenfels Training Area in Germany in April 2015. This tank is fitted with the various components of the I-MILES CVTESS (Instrumentable Multiple Integrated Laser Engagement System Combat Vehicle Tactical Engagement Simulation System) including a laser transmitter on the gun mantlet and an orange beacon on the left rear corner of the turret. The device on the turret side in front of the loader is a Main Gun Signature Simulator which contains 60 small pyrotechnic charges that are detonated to simulate the main gun firing during maneuvers. (US Army/Capt John Farmer)

Evolutionary Armor (NEA), an Ammunition Data Link (ADL) to optimize smart round effects, and the upgrade of line replaceable units (LRUs) to line replaceable modules (LRMs). GDLS was awarded a development contract for this effort in September 2012. The ECP 1A configuration eventually emerged as the M1A2 SEPv3, with the first six tanks funded in FY15 and deliveries of the FY15 tanks at the Joint Systems Manufacturing Center (JSMC) in October 2017. JSMC is the new name for the Lima Army Tank Plant.

The next stage of the process is the ECP 2, aimed at developing what will become the M1A2 SEPv4 sometime around 2020. This will continue the process of evolutionary change on a variety of systems, including a new generation of armor, upgraded sensors, and new ammunition.

The primary focus of the Abrams Lethality ECP improvements is the development of third-generation thermal imaging systems for the Gunner's Primary Sight and the Commander's Independent Thermal Viewer. The program is also adapting the Ammunition Data Link (ADL) for the forthcoming



A pair of M1A2 SEPv2 Abrams tanks of Company C, 1st Battalion, 18th Infantry Regiment, 2nd Armored Brigade Combat Team, 1st Infantry Division, from Fort Riley, Kansas, take part in *Justice Eagle*, a bilateral live-fire exercise with the Romanian Army on April 17, 2018, at Smardan Training Area, Romania. (US Army/Staff Sgt Matthew Keeler)

XM1147 Advanced Multipurpose (AMP) round. The Army is interested in the AMP round as a means to replace several existing rounds, including the M830A1 HEAT-MP-T, M908 HE-OR-T, and M1028 canister, with a single, multipurpose round. The round will feature a programmable fuze that can be set for airburst, detonation-on-impact, and delay-after-impact. The AMP works in conjunction with the new Ammunition Data Link so that the round can be immediately reprogrammed even when in the gun chamber. The Army is also developing a new APFSDS projectile, the M829E4. Additional improvements being considered include an improved environmental control system, a laser warning receiver, and vehicle smoke generation.

MARINE CORPS M1A1 IMPROVEMENTS

The US Marines Corps remains committed to the M1A1 since it faces more stringent weight restrictions than the Army due to its maritime amphibious deployment requirements. As a result, the Marine Corps did not follow the US Army's M1A1 program improvements. Instead, the Marine Corps adopted features from the Army that it considered essential, as well as improvements based on its own requirement.

The Marines have refreshed their Abrams tank fleet by means of transfers from the Army. So in 2004–07, the Army transferred 144 M1A1 tanks to the Marine Corps and a further 80 in 2007–08 which had undergone the Army's recapitalization program. The Marine Corps then added its own modifications to these tanks and sent a corresponding number of older tanks back to the Army for rehabilitation by the joint ANAD (Anniston Army Depot, Mississippi)/JSMC process.

The focus of the Marine modifications immediately after 2000 was the Firepower Enhancement Program (FEP). This was designed to improve the

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1: M1A2 SEPv2, COMPANY C, 1st BATTALION, 18th INFANTRY REGIMENT, 2nd ARMORED BRIGADE COMBAT TEAM, 1st INFANTRY DIVISION, SMARDAN, ROMANIA, DECEMBER 2017

US Army equipment is gradually shifting back to CARC Green 383 due to European commitments. Some new equipment, including the M1150 ABV, was delivered in green as early as 2013, but the process began to pick up momentum in 2017 due to the increased tempo of exercises in Europe. Curiously enough, some US Army units arriving in Germany have been repainted in German Bundeswehr green paint, though in theory at least, this should be very close in appearance to the US Army green.

In December 2017, elements of the 1st Infantry Division deployed to Romania for joint exercises. The M1A2 SEPv2 tanks of 1-18th Infantry received a hasty coat of green paint, but portions of the tank were not painted and so the CARC Tan base coat can be seen on the CROWS-LP, CITV, and other components. Some of the paint chipped off on other areas, such as the top of the gun tube, suggesting that it was some type of temporary paint. The 1st Infantry Division uses a set of intricate markings to distinguish its various component formations, the example here representing Co. C, 1-18th Armor.

2: M1A2 SEPv2, COMPANY A, 1st BATTALION, 63rd ARMOR REGIMENT, 2nd ARMORED BRIGADE COMBAT TEAM, 1st INFANTRY DIVISION, GRAFENWÖHR TRAINING AREA, GERMANY, EXERCISE *COMBINED RESOLVE X*, APRIL 2018

A year later when 1-63rd Armor deployed to Germany for spring maneuvers, their tanks had been refinished more thoroughly in CARC Green as seen here. The 1-63rd Armor uses the divisional tactical markings, but the thickness of the symbol is greater than in other battalions as is seen here with the marking for 1st Platoon, Company A, 1-63rd Armor.







This is one of the first M1A2 SEPv3 during a handover ceremony on October 4, 2017, at the JSMC in Lima, Ohio. The changes on this version are largely internal, with few distinguishing features from the M1A2 SEPv2. (US Army)

ability of the crew to engage targets faster, at greater range, and in all weather. The FEP package included HTI-SGF second-generation thermal sights, a north-finding, far-target location system, the ELRF eye-safe laser range finder, and a thermal sight for the .50cal machine gun. The development program concluded in November 2004 and the installation program in late 2005, eventually affecting 386 tanks by the time it was completed in early 2010. In 2009, the Marines began a program to fit their M1A1 tanks with External APUs. The next package of improvements was the Survivability and Lethality Enhancement program, based in large measure on the lessons of the Iraq conflict. Under this program, 160 tanks were upgraded with belly armor kits and improved driver seats. This was followed by an Abrams Suspension Upgrade (ASU), Situational Awareness enhancements (SAE), and a Slew-to-Cue feature. Slew-to-Cue allows the tank commander to automatically traverse the main gun to the same azimuth and elevation as the Stabilized Commander's Weapons Station (SCWS) sight with a single push of a button. In 2015, the Marines began to acquire the Abrams Integrated Display and Targeting System (AIDATS) that significantly improved the tank commander's displays. In 2018, the Marines began updating the M1A1 fleet with the Improved Side Armor (ISA) kit.

The Marine Corps expects to operate the M1A1 into the indefinite future, and so other improvements are likely. It's worth noting that the Marine Corps does not apply modified designations for these various improvement packages, though the US Army sometimes refers to their tanks as M1A1 MC (Marine Corps) to recognize that they incorporate features that are not identical to those on US Army M1A1 tanks.



An M1A1 Abrams Tank of the 2nd Tank Battalion, 2nd Marine Division with track-width mine plow and the centerline diverter kit on maneuver training at Fort Stewart, Georgia, on February 10, 2018. Several of the recent upgrades are evident on this tank, including the thermal sight on the commander's .50cal machine gun and the BFT/GPS antenna to the side of the Gunner Primary Sight. (US Marine Corps/Cpl Alexander Sturdivant)

ABRAMS ACTIVE PROTECTION SYSTEMS



The US Army has been investigating both hard-kill and soft-kill active protection systems (APS) for decades. These systems are typically designed to shield the tank against RPGs and antitank guided missiles (ATGM). Soft-kill systems are designed to interfere with the guidance systems of ATGMs. The US Army acquired over 3,500 VLQ-6 and VLQ-8 Missile Countermeasures Devices. These emitted an infrared signal to interfere with the optical command link between typical Soviet ATGMs and their launchers. These were fitted to some M1A1 tanks during Operation *Desert Storm*. Research was also undertaken on a variety of hard-kill APS systems including the Raytheon SLID guided munition, though none reached the production stage. Hard-kill APS systems are designed to attack the enemy rocket or missile. These usually involve some sort of small projectile or munition to destroy the warhead of the incoming rocket or missile to prevent it from detonating.

The Marine Corps conducts its M1A1 tank upgrades at a different pace from the Army. This M1A1 shows some of the features unique to the Marine Corps such as the eight-round M257 grenade launcher and the thermal imaging sight configuration on the .50cal heavy machine gun. The tan box adjacent to the Gunner's Primary Sight housing is the antenna for the Blue Force Tracker/GPS system. This is a tank of Echo Company, 4th Tank Battalion, 4th Marine Division at Camp Grayling Joint Maneuver Training Center in Michigan on July 31, 2017. (Michigan National Guard/ Spc Savannah Lang)

The US Army funded Raytheon to develop its Quick Kill APS system for the FCS program. Even after the FCS program was canceled in 2009, the Quick Kill program was continued for potential successor efforts such as the short-lived GCS (Ground Combat System). Foreign systems were also examined. The Israeli Trophy system, developed by Rafael, was rejected by the US Army in 2006 in favor of continued development of Quick Kill. The Trophy began to be deployed on Merkava tanks of the Israeli Defense Force in 2009 and it was first used in March 2011 when a Trophy-equipped Merkava 4 intercepted an antitank missile launched from Gaza. The US Congress was not happy with the slow pace of US Army APS development and appropriated additional funding in FY17 for the US Army to acquire Trophy as a non-developmental item. As a result, the FY18 budget continued to fund development of the new



One of the M1A2 SEPv2 test vehicles, fitted with the Trophy HV active protection system. The octagonal antenna of the EL/M 2133 can be seen on the side and the MEFP munition dispenser above and slightly behind the antenna. (US Army)

The M104 Wolverine heavy assault bridge was fitted with a derivative of the German Leguan bridging system. Although type classified, its production was prematurely terminated due to Army funding cuts. (US Army)



Modular APS (MAPS) program while at the same time providing immediate procurement funding for Trophy integration on the M1A2 SEPv2.

The Trophy uses a set of Elta EL/M 2133 radars mounted on the turret to detect an approaching munition. The onboard computer then tracks the munition, determines the intercept parameters, alerts the crew, and then automatically discharges an MEFP (Multiple Explosive Formed Penetrators) munition that intercepts the threat and destroys its warhead a safe distance from the tank, usually about 10–30 meters. The MEFP munition disperses about three dozen small pellets to shred the incoming warhead. Rafael teamed with Leonardo DRS in St Louis to offer the upgraded Trophy HV to the US Army. In September 2017, the Army awarded Leonardo DRS a contract for the eventual production of 261 Trophy HV kits to retrofit M1A2 SEPv2 tanks. The US Marine Corps has also indicated that it will acquire the Trophy for its own tanks.

ABRAMS TANK DERIVATIVES

Over the past decades, a variety of armored vehicles have been developed on the M1 tank chassis. General Dynamics developed the Abrams Recovery Vehicle using its own funding. However, the army preferred to stay with a less expensive alternative, the M88A2 Hercules.

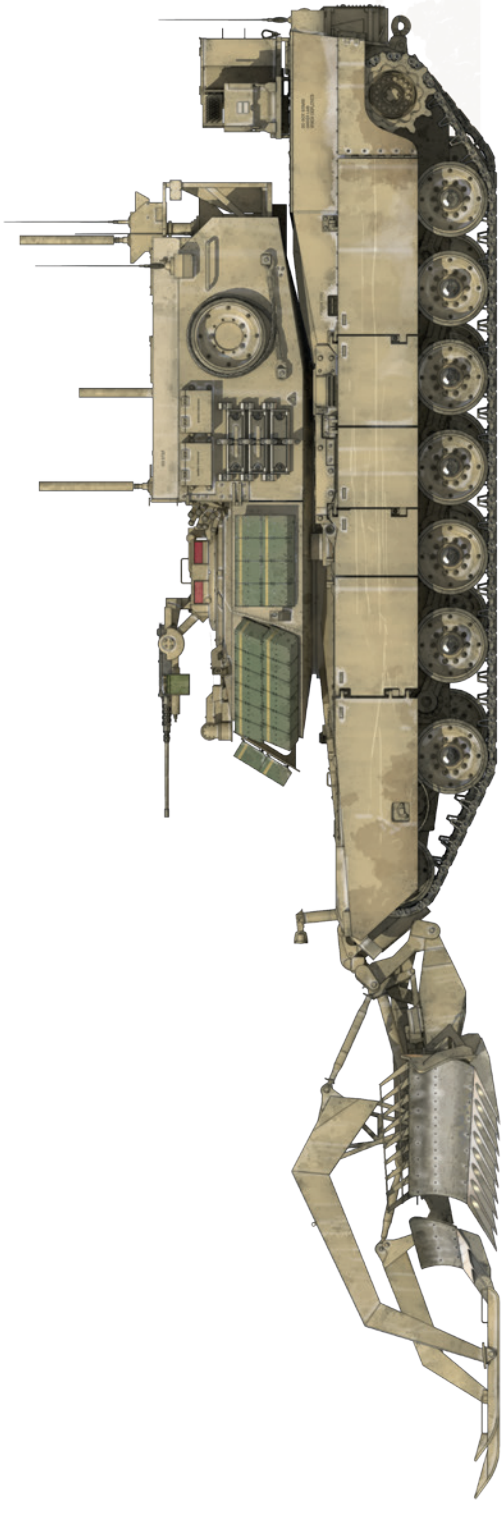
Assault Bridge Vehicles

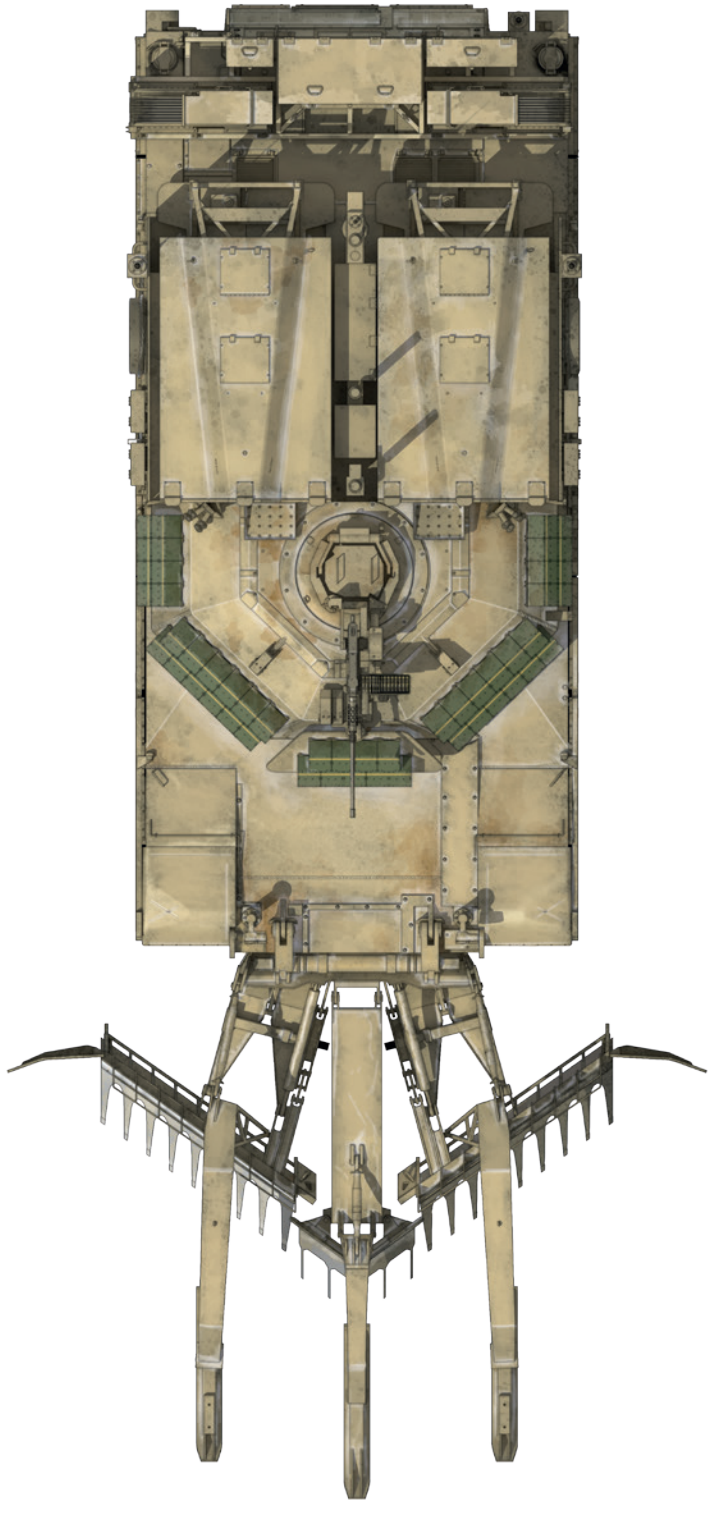
The first combat engineer vehicle was the Heavy Assault Bridge. The first version was a scissors bridge developed by BMY Inc in 1984. This was not entirely satisfactory and the Army funded GDLS starting in 1983 to develop an alternative using the German Leguan system, a 26-meter (79ft) Load Class 70 bridge. However, this program was canceled in December 1990 due

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M1150 ASSAULT BREACHER VEHICLE, MOBILE ASSAULT COMPANY, 2nd COMBAT ENGINEER BATTALION, US MARINE CORPS, CAMP LEJEUNE, 2015

Most US Marine Corps armored vehicles remained in CARC Tan 686A in the aftermath of the wars in Iraq and Afghanistan. Markings on these vehicles have generally been minimal, usually consisting of a vehicle registration number and some small safety stenciling.







The Joint Assault Bridge combines the scissors bridge from the older AVLB with a modified M1A2 SEP chassis. (US Army)

to funding cuts. This program was revived a year later based on lessons of Operation *Desert Storm*, where it was clear that the existing AVLB (Armored Vehicle Launched Bridge) based on the older M60 tank was inadequate. The M104 Wolverine heavy assault bridge was fitted with a derivative of the Leguan and mounted on an M1A2 SEP chassis. The initial plan was to build 465 of these starting in 1996. In the event, the $2.6 billion price tag for the program proved unaffordable and the program was trimmed back to only 20 vehicles funded in FY96–99. The first was delivered to the 4th Infantry Division in 2000.

The US Marine Corps remained interested in an assault bridge on the M1 chassis and initiated the Joint Assault Bridge (JAB) program. By 2010, the Army realized that its AVLB fleet was due for retirement, and the JAB effort was shifted to its control and restarted in 2011. An engineering development contract was awarded in 2012 to DRS (now Leonardo DRS) using a scissors bridge developed from the AVLB. Under the program, AVLB bridges will be upgraded to MLC 85 standard at Anniston Army Depot and then mated



This is one of the pilots of the M1 Grizzly Breacher Vehicles showing the large excavator arm on the right side of the vehicle. Although tests showed it to be an excellent design, budget shortages led to its cancelation. (Author)

to a modified M1A2 SEP chassis. Initial funding was included in the FY16 budget and DRS was awarded a production contract in May 2016 for up to 273 JAB, with initial deliveries in 2018.



The Panther II Robotic Countermine Vehicle (ROCV) could be fitted with either the mine-clearing roller or mine-clearing rake as seen here. There were also experiments in fitting it with a tow-behind roller kit to deal with mines not cleared by the forward rollers. (US Army)

Combat Engineer Breacher Vehicles

The M1 Grizzly Breacher program was started by the US Army in 1992, based on lessons of Operation *Desert Storm* that concluded that the army engineer units needed a vehicle to assist the maneuver force in rapidly breaching minefields, rubble, terrain obstructions, and other obstacles. Development was undertaken by BMY (subsequently part of United Defense) and prototypes were delivered in the late summer of 1995. The vehicle was fitted with a large, hydraulically operated power arm on the right side that could be extended 9 meters with a bucket capacity of 1.2 cubic meters. At the front of the vehicle was a 4.2-meter full-width mine-clearing blade (MCB). The power arm was intended to reduce berms or other obstacles and to fill antitank ditches and other obstructions. The MCB lifted and pushed mines to the side to create a cleared lane. Each corps-level engineer brigade would have had 36 Grizzlies and 36 Wolverine heavy assault bridges. The army planned to acquire 366 Grizzlies, with the first unit equipped in 2004. In the event, on December 27, 1999, the acquisition program was canceled due to the high cost of the vehicle.

The threat of mines during peacekeeping operations in Bosnia led to a 1995 effort to develop a remote-control mine-clearing system called Panther, based on a surplus M60A1 tank chassis fitted with mine-clearing rollers. Seven of these were built and were used with success in Bosnia by the 16th and 23rd Engineer Battalions in 1996–97. Due to the difficulty in obtaining spare parts, the system was shifted to surplus IPM1 tanks as the



An M1150 Assault Breacher Vehicle of the Mobile Assault Company, 2nd Combat Engineer Battalion, leaves to conduct a route clearance mission in support of Operation *Dynamic Partnership* in Shurakay, Helmand province, Afghanistan, on February 13, 2013. The ABV can be fitted with different breaching tools in the front of the vehicle and in this case is equipped with the Full-Width Mine Plow. The claw-like devices are used to help establish the soil depth at which the mine rakes are set for mine clearing. (US Marine Corps/Cpl Alejandro Pena)



An M1150 Assault Breacher Vehicle of the Mobile Assault Company, 2nd Combat Engineer Battalion, uses its Combat Dozer Blade during an obstacle breaching exercise at Camp Lejeune, North Carolina, on September 17, 2015. The ABV has the lid over the line demolition charge launcher in the open position. (US Marine Corps/Cpl Paul S. Martinez)

Panther II Robotic Countermine Vehicle (ROCV). These turretless vehicles could be operated by a crew of two, or remotely operated using Omnitech's Standardized Tele-operation System (STS) with the control system fitted in an accompanying HMMWV (High Mobility Multipurpose Wheeled Vehicle, colloquially Humvee). Six of these vehicles were built in 1990, but the Panther II was never type classified. Two of these were deployed to Iraq with the 9th Engineer Battalion in 2007 and employed in the Tikrit area.

The M1150 Assault Breacher Vehicle (ABV) was another US Marine Corps initiative in 2002 to develop an armored engineer vehicle to conduct rapid breaching of minefields based on the lessons from Operation *Desert Storm*. The program was funded using the Pentagon's Foreign Comparative Testing budget, with many of the specialized engineering devices coming from Pearson Engineering in the UK. The M1150 ABV was mounted on an M1A1 chassis and the conversion work was undertaken at the Anniston Army Depot.

In contrast to the US Army's Grizzly program, the ABV's main breaching device was a Linear Demolition Charge System (LDCS), consisting of an M58A3 Linear Demolition Charge propelled by an MK22 Mod 4 Rocket. Two line charges are coiled up like rope in a large container on the rear of the ABV. When pulled out of the launch container by the rocket, the line

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AUSTRALIAN M1A1 SA, B SQUADRON, AUSTRALIAN 1st ARMOURED REGIMENT, SHOALWATER, QUEENSLAND, AUSTRALIA, 2011

The Australian M1A1 SA tanks have been painted in AUSCAM, a three-color scheme consisting of lusterless olive drab, tan, and black. These generally follow a standard pattern, but there is some variation between individual tanks, especially after repainting. The national insignia, a red kangaroo, is painted on the side of the turret box. The markings include a vehicle registration number, in this case 207048. The vehicle name is painted on the side, this one is "BRIANNA," usually starting in the squadron letter. The tank number, on a removeable metal plate, also employs the squadron letter. The stenciling on the tank is in black when painted on tan or olive drab areas, and in tan when on black areas.


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BRIANNA
207048
207048



An M1150 Assault Breacher Vehicle from 8th Brigade Engineer Battalion, 2nd Armored Brigade Combat Team, 1st Cavalry Division launches its M58A3 Linear Demolition Charge with an MK22 Mod 4 Rocket at the Rodriguez Live Fire Complex in South Korea. (US Army/Sgt Patrick Eakin)

charge is 350ft long and contains 1,750lb of C-4 explosive. After the line charge is deposited over the minefield, it is remotely detonated, resulting in the sympathetic detonation of any nearby mines and thereby creating a safe path through the minefield. A Lane Marking System fitted to the rear deck of the ABV automatically marks the cleared path behind the ABV. The ABV is also fitted with a modular Engineer Breaching System that includes a Full-Width Mine Plow and a Combat Dozer Blade. Five pilots were built and operational trials were completed in February 2007. Full-scale production was authorized in November 2007.

The Marine Corps began acquiring 55 M1150 ABVs in 2007, with first deliveries in November 2008. The US Army decided to join the program in 2008 and funded 120 vehicles through the FY18 budget. The first ABV combat deployment was with the US Marine Corps in Afghanistan in February 2009, when Marines attacked a Taliban stronghold near Now Zad in Helmand province during Operation *Cobra's Anger*. The ABVs proved to be extremely suitable in rapidly breaching areas infested with IEDs. The ABV was unofficially nicknamed "The Shredder."



A US Marine Corps Assault Breacher Vehicle detonates an M58A3 Linear Demolition Charge during a training exercise at the Twenty-nine Palms Marine Corps Air Ground Combat Center in California on February 6, 2015. The line charge contains 1,750lb of C-4 explosive. (US Air Force/Staff Sgt Amy F. Picard)

ABRAMS EXPORT



A surrealistic photo of an Australian M1A1 SA tank enveloped in colored smoke while on maneuvers in the Shoalwater Bay Training Area in Queensland, Australia, on July 14, 2015, during the *Talisman Sabre* exercise. (US Army/ Spc Jordan Talbot)

Australia

After considering the adoption of the surplus Leopard 2 or Challenger 2 tanks to replace the existing Leopard AS1 main battle tank force, in March 2004, the Australian Defence Force decided to acquire the M1A1 as its next MBT. A total of 59 tanks were acquired, with deliveries in 2005–06 and initial deployment in 2007. These tanks had been modernized through the AIM program and were in the M1A1 SA configuration. Australia also purchased the TUSK kit for its Abrams fleet and has begun to consider potential M1A1 upgrades, and potentially a larger number of tanks.

Egypt

During the 1980s, Field Marshal Abd al-Halim Abu Ghazala recommended that Egypt acquire the M1A1 tank by means of co-production rather than direct purchase as a means to reduce overall costs and to strengthen Egypt's defensive industrial base. The program started in 1984 with the creation of Factory No. 200 near Cairo. The original plan called for 25 tanks to be built in the US, followed by Egyptian production increasing at each level until all 530 M1A1 tanks were completed. The Egyptian program is based on kits provided by GDLS, with the local content increasing as the factory gained experience. The first production increment included 75 tanks built in Egypt using kits provided by GDLS in the United States, with the first being completed in 1992–93.

The Egyptian co-production effort hit a major snag in 1993 due to the unexpectedly high costs of technology transfer. According to a 1993 GAO report, the co-production scheme would raise the overall cost of the acquisition program from $1.9 billion to $2.7 billion compared to direct purchase of the tanks from the US. In the event, the Egyptian government decided that the advantages of local co-production outweighed the increased costs, and the program proceeded. Delivery of the first batch of 555 M1A1 tanks was completed in December 1998.



An Egyptian Army M1A1 tank during training exercise at the Mohamed Naguib Military Base in September 2017, part of *Bright Star 17* maneuvers. (US Air Force/Staff Sgt Michael Battles)



An Iraqi M1A1 SA tank of the 1st Company, 2nd Regiment, 34th Brigade, 9th Iraqi Army fires a shot downrange at the Besmaya Combat Training Center on September 27, 2011. (US Forces Iraq/Spc Timothy Koster)

In March 1999, the two governments agreed to another increment of 100 tanks, bringing the total to 655 Abrams tanks. This was followed by similar increases to 755 tanks in August 2001, to 880 tanks in October 2003, to 1,005 tanks in August 2007, and to 1,130 Abrams in July 2011. The 2011 increment was delayed until 2015 due to political disagreements between the two governments.

Iraq

In December 2008, the US government agreed to sell Iraq 140 M1A1 AIM tanks as part of the reconstruction program. GDLS received a production contract for these tanks in March 2009 and they were delivered through September 2011. The tanks were deployed with the four tank regiments of the 9th Mechanized Division. Each regiment was issued 35 M1A1s and two M88A2 recovery vehicles. The Iraqi Abrams first saw heavy combat against the ISIS insurgency in northern Iraq in 2014, and a substantial number of M1A1 tanks were lost in these battles. Some abandoned tanks were attacked by US aircraft to prevent their capture. ISIS units apparently captured and used Abrams tanks on several occasions.

The status of some of these Abrams tanks created a controversy in late 2017 and early 2018 when it became clear that the Iranian-backed Hashd al-Shaabi Popular Mobilization Force militias were operating eight or nine Abrams tanks, allegedly recaptured from ISIS. The US government formally warned the Iraqi government in late 2017 that it would halt the technical support of the Abrams fleet being conducted by GDLS contractors in Iraq unless the tanks were returned to Iraqi Army control. Most of the GDLS workforce departed in December 2017.

A second order for 175 M1A1 tanks for the Iraqi Army was approved in December 2014, though the status of this sale was put in doubt by the 2017–18 controversy.

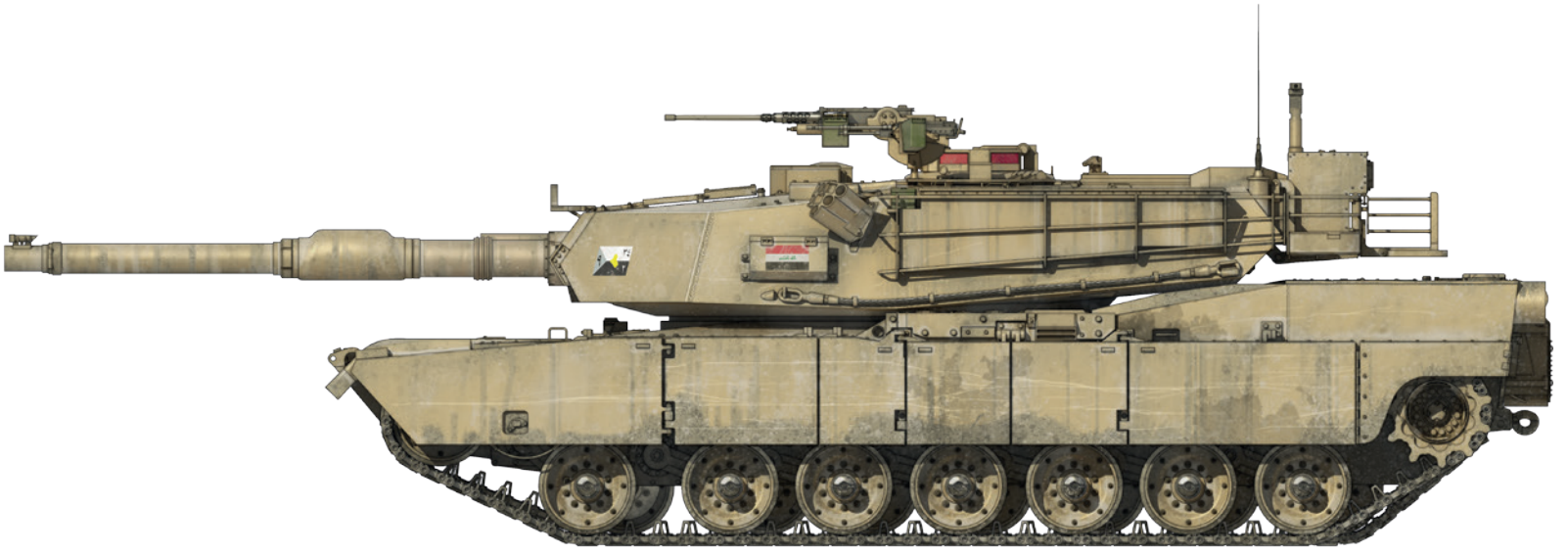
Kuwait

In the wake of the 1990–91 Gulf War, Kuwait decided to acquire the M1A2 tank to replace its M-84 (Yugoslav-manufactured T-72) tank fleet. The first

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IRAQI M1A1 SA, 9th ARMORED DIVISION, MOSUL, 2014

The Iraqi M1A1 SA tanks were delivered in the usual CARC Tan color scheme. Most of these tanks were issued to the 9th Armored Division. Originally, they were issued to two battalions of the 36th Regiment, but it would appear that these battalions were reassigned. During the 2014 fighting, there were four M1A1 battalions in the division, 1-34th, 2-34th, 4-35th, and 5-35th. The regimental insignia follow a flag pattern with the 9th Armored Division indicated by a black "9" over a grey triangle at the left of the marking. The remaining marking is divided into two with the regimental number in the upper right and the battalion number in the lower right. As shown in the illustration here, the 1-34th (upper left) uses white/white; 2-34th (lower left) uses white/black; 4-35th (upper right) uses black/blue; and 5-35th (lower right) uses black/black. The Iraqi Army flag is carried on the smoke grenade boxes on either side of the turret. The side profiles and front profile to the left show a tank of 2nd Battalion, 34th Regiment, 9th Armored Division while the front profile to the right shows a tank of 4th Battalion, 35th Regiment, 9th Armored Division.




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A live-fire demonstration of Kuwaiti Land Forces M1A1 tanks at Camp Udari on February 21, 2018, with a group of Kuwait BMP-3 infantry fighting vehicles in the foreground. (US Army/Staff Sgt Adriana M. Diaz-Brown)

16 tanks were delivered in 1995 and the remainder in 1996, bringing the total to 219 M1A2 tanks. The Kuwaiti tanks had some features unique to this production batch, such as the AN/VAS-3 driver's thermal imaging sight. In December 2016, an agreement was reached to modernize the Kuwait tank fleet by running them through the recapitalization program at Anniston and Lima to bring them up to M1A2 SEPv2 standards. This process is expected to include some features specifically requested by Kuwait, so this version is sometimes called the M1A2 K.

Morocco

In June 2011, an agreement was reached between Morocco and the United States over the sale of 200 M1A1 tanks, and a contract for the first batch of 50 M1A1 SA tanks was awarded to GDLS in August 2015. The first 22 tanks were delivered to Morocco in 2016.

Saudi Arabia

In 1992, Saudi Arabia selected the M1A2 Abrams for its next-generation MBT. A total of 465 tanks were authorized, consisting of an initial batch of 315 and a possible follow-on batch of 150 with deliveries of the first batch completed in 1994. In July 2006, there was an agreement to upgrade the 315 Saudi M1A2 tanks to M1A2S (Saudi) standards as well as to add a further 59 M1A1 AIM tanks. The M1A2S configuration resulted from the tanks being run through the Anniston/Lima recapitalization program. The Saudi M1A2 force first saw combat in Yemen in 2016 against the Houthi rebel forces, and there were press reports that as many as 20 Saudi Abrams had been knocked out in combat. In August 2016, there was another agreement for sale of a further 153 M1A2S Abrams tanks, probably configured to M1A2 SEPv3 standards.



A Saudi M1A2S on display at the IDEX-13 exhibition in Abu Dhabi, United Arab Emirates, in February 2013. (Author)

FURTHER READING

Several developmental histories of the M1 Abrams were published shortly after its initial production, notably the Hunnicutt history. With the exception of the Newsome book, most titles since then have been photo albums aimed at modelers.

This book was based on official US government reports and documents. Details of the M1A1 and M1A2 modification and upgrade program came primarily from various annual editions of the Program Element Descriptors for the annual Department of Defense Presidential budget requests: US Army Procurement of Wheeled and Tracked Combat Vehicles (WTCV) and the comparable volumes for the US Marine Corps. Details of service introduction dates and deployments came primarily from the periodic US Army Weapons Systems Handbook. A variety of other reports were also used, including reports by the Program Manager-Ground Combat Vehicles (Tank and Automotive Research Development Command – TARDEC); Director, Operational Test and Evaluation (DOT&E), and Government Accountability Office. Data on M1 tank exports came primarily from reports and announcements of the Defense Security and Cooperation Agency.

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GLOSSARY

AAPU	Alternate APU; based on batteries rather than generator
ABCT	Armor Brigade Combat Team
ABV	Assault Breacher Vehicle
AIM	Abrams Integrated Management
ANAD	Anniston Army Depot, Mississippi
APFSDS	Armor-piercing, Fin-stabilized, Discarding-Sabot projectile
APS	Active Protection System
APU	Auxiliary Power Unit
BFT	Blue Force Tracker
CITV	Commander's Independent Thermal Viewer
CREW	Counter Remote-Controlled IED Electronic Warfare
CROWS	Common Remotely Operated Weapon Station
DATP	Detroit Army Tank Plant, Michigan
EAPU	External APU, usually fitted at left rear of turret in bustle rack
ECP	Engineering Change Proposal
EFP	Explosively formed penetrator
ELRF	Eye-safe laser range finder
FBCB2	Force XXI Battle Command Brigade and Below
FCS	Future Combat System
FLIR	Forward looking infrared, alternate term for thermal imager
FSED	Full-scale engineering-manufacturing development
FVRDE	Fighting Vehicles Research and Development Establishment in Chobham, Surrey, UK
FY	Fiscal Year (Federal); currently from 1 October to 30 September, so FY17 was Oct 1, 2016–Sep 30, 2017
GAO	Government Accounting Office; now Government Accountability Office
GDLS	General Dynamics Land Systems
GPS	Global positioning satellite; also Gunner's Primary Sight
HA	Heavy Armor
HBCT	Heavy Brigade Combat Team
HEAT	High Explosive Antitank, projectile using a shaped-charge warhead
HTI-SGF	Horizontal-technology-integration second-generation FLIR
ICWS	Improved Commander's Weapon Station
IED	Improvised Explosive Device
JAB	Joint Assault Bridge
JSMC	Joint Systems Manufacturing Center, formerly Lima Army Tank Plant
LATP	Lima Army Tank Plant, Ohio
LRIP	Low-rate initial production
MBT	Main battle tank
OSD	Office of the Secretary of Defense
PLGR	Precision Lightweight GPS Receiver
RPG	Rocket-propelled grenade such as Soviet RPG-7
SA	Situational Awareness
SEP	System Enhancement Program
TIGER	Total Integrated Engine Revitalization
TMS	Thermal Management System to cool tank's electronics
TUSK	Tank Urban Survivability Kit
UAAPU	Under Armor APU